

## Table of Contents

|  |          |
|--|----------|
| <b>Chapter 1. Introduction.....</b>                      | <b>2</b> |
| 1.1 General Description .....                            | 2        |
| 1.2 AP3928 Key Features .....                            | 2        |
| 1.3 Applications .....                                   | 2        |
| 1.4 Board Pictures .....                                 | 2        |
| <b>Chapter 2. Power Supply Specification .....</b>       | <b>3</b> |
| 2.1 System Performance.....                              | 3        |
| 2.2 Environment.....                                     | 3        |
| <b>Chapter 3. Schematic and Bill of Material .....</b>   | <b>4</b> |
| 3.1 Schematic.....                                       | 4        |
| 3.2 Bill of Material.....                                | 4        |
| <b>Chapter 4. The Evaluation Board Connections .....</b> | <b>5</b> |
| 4.1 PCB Layout .....                                     | 5        |
| 4.2 Circuit Description .....                            | 5        |
| 4.2.1 Input EMI Filtering .....                          | 5        |
| 4.2.2 Control IC.....                                    | 5        |
| 4.2.3 Output Rectification .....                         | 5        |
| 4.2.4 Output Feedback .....                              | 5        |
| 4.3 Quick Start Guide.....                               | 5        |
| <b>Chapter 5. System Test .....</b>                      | <b>6</b> |
| 5.1 Input & Output Characteristics.....                  | 6        |
| 5.1.1 Input Standby Power .....                          | 6        |
| 5.1.2 Efficiency .....                                   | 6        |
| 5.1.3 Line and Load Regulation .....                     | 7        |
| 5.2 Key Performance Test .....                           | 9        |
| 5.2.1 Start up Performance .....                         | 9        |
| 5.2.2 Rise Time .....                                    | 10       |
| 5.2.3 Voltage Stress .....                               | 11       |
| 5.2.4 Output Ripple & Noise.....                         | 12       |
| 5.2.5 Dynamic Response.....                              | 13       |
| 5.3 Protection Test .....                                | 14       |
| 5.3.1 Short Circuit Protection (SCP) Test .....          | 14       |
| 5.3.2 Open Loop Detection (OLD) Protection Test.....     | 14       |
| 5.3.3 Over Load Protection (OLP) Test .....              | 15       |
| 5.4 Thermal Test .....                                   | 15       |
| 5.5 System EMI Scan.....                                 | 16       |
| 5.5.1 Conducted EMI Test of 230V@full load .....         | 16       |
| 5.5.2 Conducted EMI Test of 110V@full load .....         | 17       |

## Chapter 1. Introduction

### 1.1 General Description

AP3928 is an off-line universal AC Voltage input step-down regulator which provides accurate constant voltage (CV) output, outstanding low standby power, high efficiency at light loading and excellent dynamic response based on non-isolated buck topology.

The AP3928 EV1 Evaluation Board provides a good design example for a cost-effective 9.9W single output 18V/550mA power application used in home appliances.

### 1.2 AP3928 Key Features

- Universal 85V to 265V  $V_{AC}$  Input
- Internal MOSFET 700V (6.5 $\Omega$  max)
- Maximum 600mA rated Output current
- Low Standby Power Consumption (<30mW at no load)
- High Light-Loading and Average efficiency can meet DOE and CoC requirement
- Frequency Modulation to suppress EMI to meet EN55022 class B
- Rich Protection including: OTP, OLP, OLD, SCP
- Extremely low system component count
- Totally Lead-free & Fully RoHS Compliant (SO-8)
- Halogen and Antimony Free. "Green" Device

### 1.3 Applications

- Non-Isolated Home Appliances: AC Fans, Rice Cookers, Air conditioners, Coffee Machines, Soy Milk Machines, etc.
- Auxiliary Power for IoT Devices.

### 1.4 Board Pictures

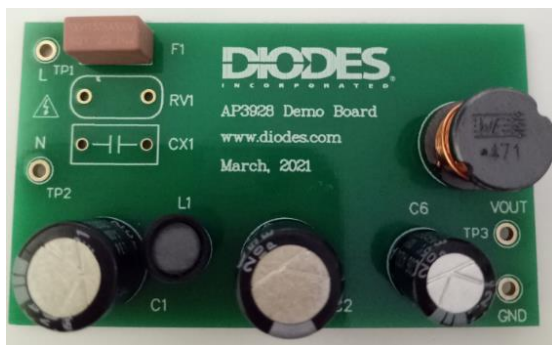


Figure 1: Top View

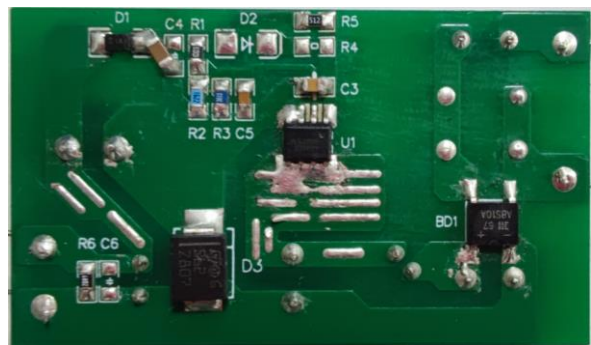


Figure 2: Bottom View

## Chapter 2. Power Supply Specification

### 2.1 System Performance

The system performance contains input/output characters, specifications, EMC, protections, and etc.

|                                |         | Min.       | Typ.    | Max.      | Comments                                       |
|--------------------------------|---------|------------|---------|-----------|--|
| <b>Input Characters</b>        |         |            |         |           |  |
| Input AC voltage rating        |         | 100V/60Hz  | 115/230 | 240V/50Hz | Two wires, no PE                               |
| Input AC voltage range         |         | 85V/60Hz   | -       | 265V/50Hz |  |
| Input AC frequency range       |         | 47Hz       | 50/60   | 63Hz      |  |
| <b>Output Characters</b>       |         |            |         |           |  |
| Output voltage                 |         | 17.1V      | 18V     | 18.9V     | Tested at board terminal                       |
| Output tolerance               |         | -          |         | ±5%       |  |
| Loading current                |         |            | 550     |           | mA   |
| <b>Measurement Performance</b> |         |            |         |           |  |
| Standby power                  |         | -          | 16.5mW  |           | @230V/50Hz                                     |
| Efficiency standard            | 115Vac  | 10% load   | 87.88%  | -         | DoE VI: 71.97%<br>CoC V5 tier 2: 72.03%/62.03% |
|                                |         | Avg. eff.  | 86.81%  | -         |  |
|                                | 230Vac  | 10% load   | 85.39%  | -         |  |
|                                |         | Avg. eff.  | 85.82%  | -         |  |
| Load regulation                |         | -          | ±2.19%  | -         | Tested at board terminal                       |
| Line regulation                |         | -          | ±0.28%  | -         | Tested at board terminal                       |
| Ripple & Noise                 |         | -          | 57.6mV  | -         | @full load and full voltage range              |
| Startup time                   |         | -          | 18.6ms  | -         | 85V/60Hz                                       |
| <b>EMC Test</b>                |         |            |         |           |  |
| ESD test                       | Air     | 15kV       | -       | -         | @100Ω concrete resistor                        |
|                                | Contact | 8kV        | -       | -         |  |
| EFT test                       |         | 2kV        | -       | -         | ±5kHz/100kHz                                   |
| Surge Test                     |         | 1kV        | -       | -         | Differential mode, 2ohm, 1.2/50us              |
| Conduction EMI                 | 110V    | 6dB margin | -       | -         | FCC Part 15 Class B                            |
|                                | 230V    | 6dB margin | -       | -         | EN55022  |
| <b>Protection Functions</b>    |         |            |         |           |  |
| SCP test                       |         | -          | -       | -         | OK   |
| OLD test                       |         | -          | -       | -         | OK   |
| OLP test                       |         | -          | 8.2V    | -         | OK   |
| OTP test                       |         | 135°C      | 150°C   | 165°C     | OK(IC internal Temp)                           |

### 2.2 Environment

|                        |              |
|------------------------|--------------|
| Operation temperature: | -20°C~85°C   |
| Operation Humidity:    | 20%~90% R.H. |
| Storage temperature:   | 0~40°C       |
| Storage Humidity:      | 0%~95% R.H.  |

### Chapter 3. Schematic and Bill of Material

#### 3.1 Schematic

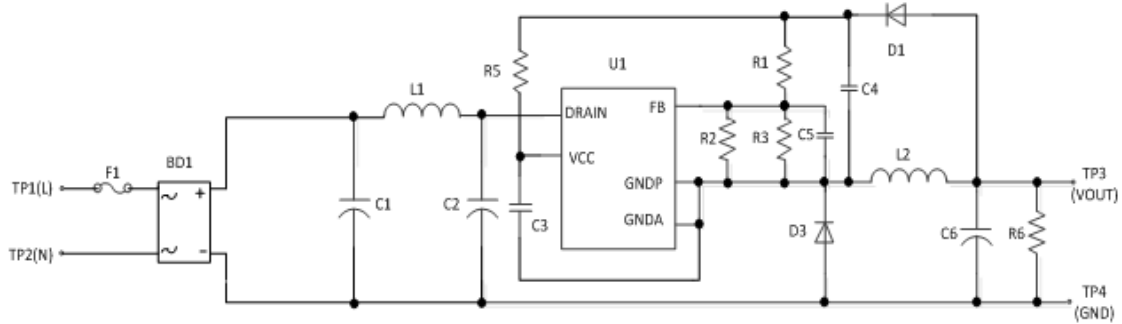


Figure 3: Evaluation Board Schematic

#### 3.2 Bill of Material

Table 1: Bill of Material

| Items        | Designator | Description                       | Footprint     | Qty. | Manufacturer |
|--------------|------------|-----------------------------------|---------------|------|--------------|
| 1            | F1         | 3.15A/300V; Fuse                  | 8*4*8mm       | 1    | OAHE         |
| 2            | BD1        | ABS10A                            | SOPA-4        | 1    | Diodes       |
| 3            | C1, C2     | 10uF/400V, Electrolytic capacitor | Φ10*13mm      | 2    | Rubycon      |
| 4            | C3         | 2.2μF/25V, X7R                    | SMD 0805      | 1    | Murata       |
| 5            | C4         | 1μF/50V, X7R                      | SMD 1206      | 1    | Murata       |
| 6            | C5         | 1.5nF/50V, X7R                    | SMD 0805      | 1    | Murata       |
| 7            | C6         | 220μF/35V, Electrolytic capacitor | Φ8*12mm       | 1    | Rubycon      |
| 8            | D1         | RS1MSWF; Fast type diode          | SOD123F       | 1    | Diodes       |
| 9            | D3         | STTH2R06S; Fast diode, 2A/600V    | SMC           | 1    | ST           |
| 10           | L1         | 220μH; Inductor, 0.96Ω, 0.5A      | DIP, Φ5*8mm   | 1    | Würth        |
| 11           | L2         | 470μH; Inductor, 0.47Ω, 1.15A     | DIP, Φ10*15mm | 1    | Würth        |
| 12           | R1         | 100kΩ                             | SMD 0805, 1%  | 1    | Yageo        |
| 13           | R2         | 16.2kΩ                            | SMD 0805, 1%  | 1    | Yageo        |
| 14           | R3         | 300.1kΩ                           | SMD 0805, 1%  | 1    | Yageo        |
| 15           | R5         | 5.1kΩ                             | SMD 0805, 5%  | 1    | Yageo        |
| 16           | R6         | 68kΩ                              | SMD 0805, 5%  | 1    | Yageo        |
| 17           | U1         | AP3928                            | SO-8          | 1    | Diodes       |
| <b>Total</b> |            | 18pcs                             |               |      |              |

## Chapter 4. The Evaluation Board Connections

### 4.1 PCB Layout

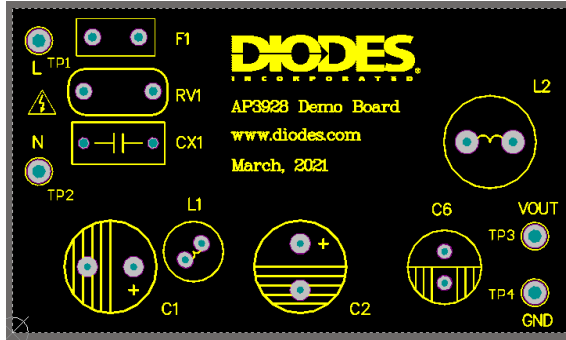


Figure 4: PCB Board Layout Top View

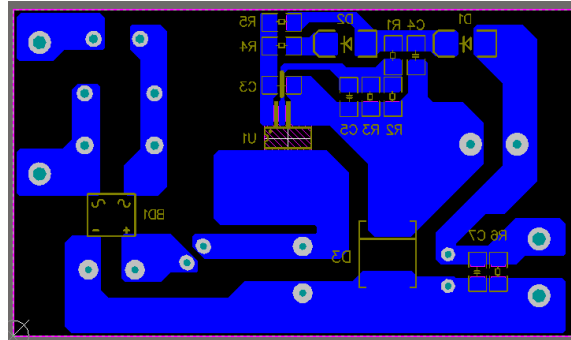


Figure 5: PCB Board Layout Bottom View

### 4.2 Circuit Description

#### 4.2.1 Input EMI Filtering

The input stage is composed of fusible resistor F1, rectifier bridge DB1, filtering inductor L1, Capacitors C1 and C2. Resistor F1 is a flame proof, fusible, wire-wound resistor. It limits inrush current to safe levels for input rectifier diodes, provides differential mode noise reduction and acts as an input fuse in the event of short circuit.

#### 4.2.2 Control IC

AP3928 co-packages a 700V power MOSFET and control circuitry into a cost-effective SO-8 package. The device is self-starting from the Drain pin with local supply decoupling provided by a small capacitor C3 (at least 100nF) connected to the BP pin when AC source is applied.

#### 4.2.3 Output Rectification

During the ON time of U1, current ramps in L2 and is simultaneously delivered to the load. During the OFF time the inductor current ramps down via the free-wheeling diode D3, feedback diode D1, and the load. Diode D3 should be an ultra-fast diodes ( $T_{rr} < 50\text{ns}$  or lower). Capacitor C3 should be selected to have an adequate ripple margin (low ESR type).

#### 4.2.4 Output Feedback

The voltage across L2 is rectified by C4 and D1 during the off-time of U1. For forward voltage drop of D1 and D3 is approximately equal, the voltage across C4 tracks the output voltage. To provide a feedback signal, the voltage across C4 is divided by R1 and R2/R3. This voltage is specified for U1 at FB pin (2.5V). This allows the simple feedback to meet the required overall output tolerance of  $\pm 5\%$  at rated output current.

### 4.3 Quick Start Guide

1. The evaluation board is preset at 18V/550mA 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" & "N" connectors on the left side of the board.
4. Turn on the AC main switch.
5. Measure "+V" & "GND" connectors to ensure correct output voltage, 18V.

**CAUTION:** This EV board is non-isolated. Do not touch anywhere there are electrical connections because they are all coupled to high voltage potential.

### Chapter 5. System Test

#### 5.1 Input & Output Characteristics

##### 5.1.1 Input Standby Power

Standby power and output voltage is measured after 10-minute aging. The voltage data is tested at the PCB terminal. All data is tested at ambient temperature.

Table 2: Standby Power and Output Voltage @ no load

| AC input Voltage | Pin (mW) | Vo (V) |
|------------------|----------|--------|
| 85V/60Hz         | 13.2     | 19.025 |
| 115V/60Hz        | 13.7     | 19.015 |
| 230V/50Hz        | 15.8     | 19.006 |
| 265V/50Hz        | 16.5     | 18.999 |

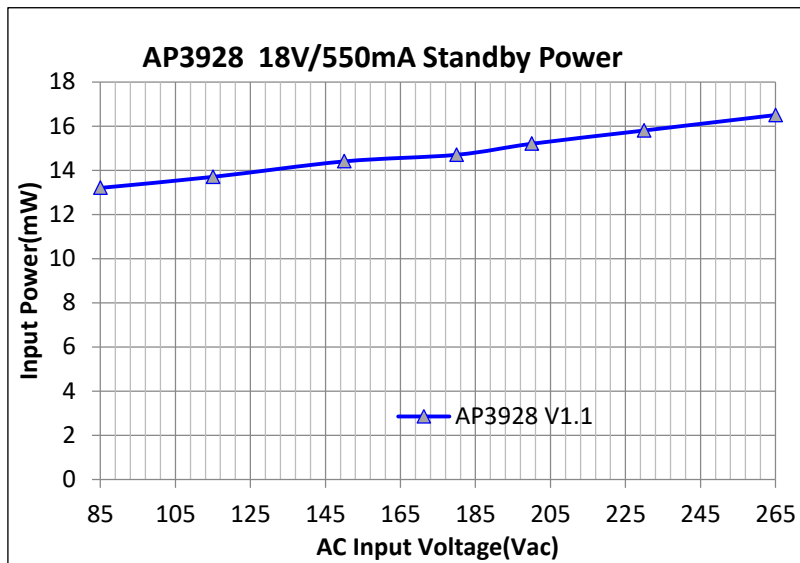


Figure 6: Standby Power versus Vin Curve

##### 5.1.2 Efficiency

The efficiency data is measured after 10-minute aging, and it is tested at the PCB terminal. All the data is tested at ambient temperature.

Table 3: Conversion Efficiency

| AC input voltage | Items          | 10%    | 25%    | 50%    | 75%    | 100%    | Avg. Eff.     |
|------------------|----------------|--------|--------|--------|--------|---------|---------------|
| 115V/60Hz        | Vo (V)         | 18.603 | 18.537 | 18.514 | 18.513 | 18.502  | <b>86.81%</b> |
|                  | Io (mA)        | 55     | 137.5  | 275    | 412.5  | 550     |               |
|                  | Pin (W)        | 1.0231 | 2.5488 | 5.0913 | 7.6366 | 10.1761 |               |
|                  | Efficiency (%) | 87.88% | 87.24% | 87.39% | 86.54% | 86.07%  |               |
| 230V/50Hz        | Vo (V)         | 18.565 | 18.513 | 18.491 | 18.492 | 18.488  | <b>85.82%</b> |
|                  | Io (mA)        | 55     | 137.5  | 275    | 412.5  | 550     |               |
|                  | Pin (W)        | 1.0211 | 2.5455 | 5.0851 | 7.6279 | 10.1684 |               |
|                  | Efficiency (%) | 85.39% | 85.04% | 85.47% | 86.56% | 86.24%  |               |

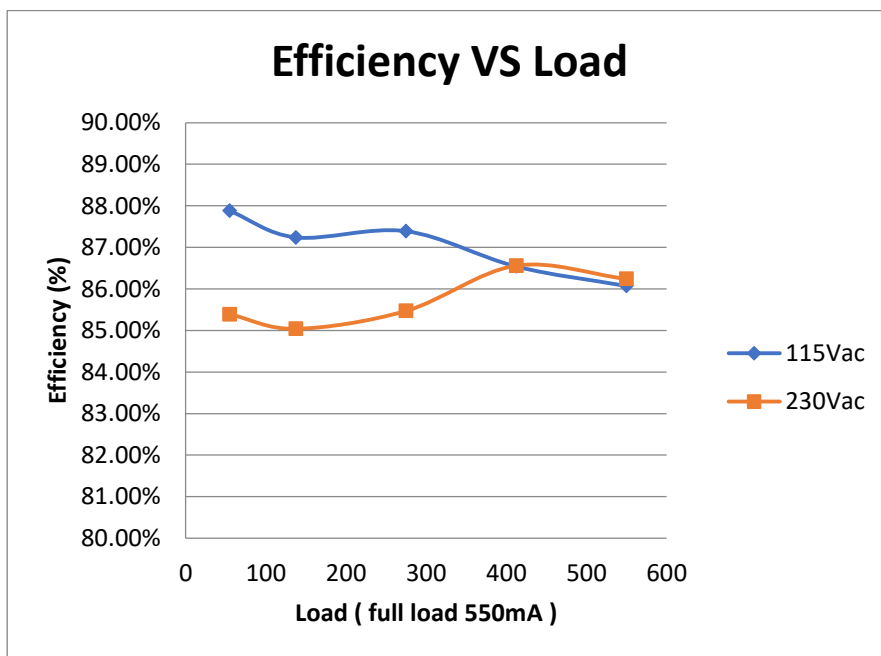


Figure 7: Efficiency versus Loading Curve

1.4.1

### 5.1.3 Line and Load Regulation

The line and load regulation data is measured after 10-minute aging. The voltage data is tested at the PCB terminal. All the data is tested at ambient temperature.

Table 4: Line and Load Regulation Data

| AC input voltage       | Loading(mA) |        |        |        |        |                 |               |
|------------------------|-------------|--------|--------|--------|--------|-----------------|---------------|
|                        | 0           | 50     | 100    | 150    | 200    | 250             | 300           |
| 85Vac/60Hz             | 19.215      | 18.654 | 18.572 | 18.532 | 18.524 | 18.516          | 18.512        |
| 115Vac/60Hz            | 19.206      | 18.603 | 18.569 | 18.537 | 18.526 | 18.518          | 18.514        |
| 230Vac/50Hz            | 19.312      | 18.565 | 18.538 | 18.513 | 18.504 | 18.496          | 18.495        |
| 265Vac/50Hz            | 19.315      | 18.556 | 18.530 | 18.512 | 18.505 | 18.501          | 18.498        |
| <b>Line Regulation</b> | ±0.28%      | ±0.26% | ±0.11% | ±0.08% | ±0.06% | ±0.06%          | ±0.05%        |
| AC input voltage       | Loading(mA) |        |        |        |        | Load Regulation | CV Regulation |
|                        | 350         | 400    | 450    | 500    | 550    |                 |               |
| 85Vac/60Hz             | 18.503      | 18.494 | 18.489 | 18.485 | 18.483 | ±1.94%          | ±4.05%        |
| 115Vac/60Hz            | 18.513      | 18.511 | 18.509 | 18.506 | 18.502 | ±1.87%          |               |
| 230Vac/50Hz            | 18.493      | 18.492 | 18.491 | 18.489 | 18.488 | ±2.18%          |               |
| 265Vac/50Hz            | 18.495      | 18.493 | 18.491 | 18.488 | 18.487 | ±2.19%          |               |
| <b>Line Regulation</b> | ±0.05%      | ±0.05% | ±0.06% | ±0.06% | ±0.05% | -               |               |

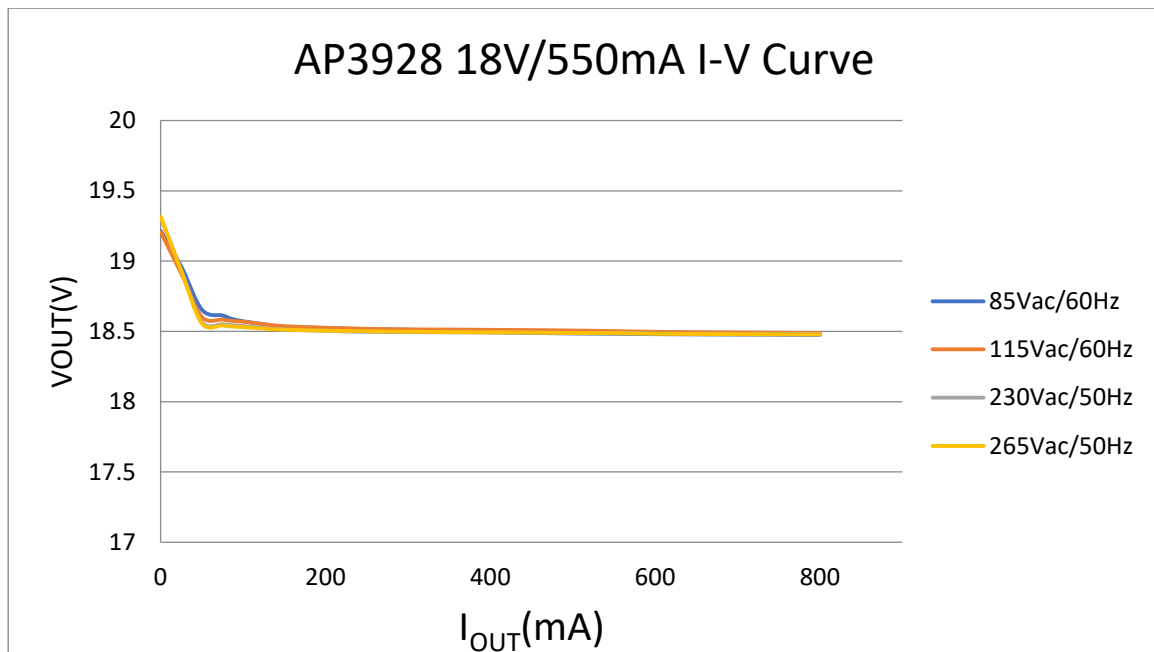


Figure 8: Output Voltage versus Loading Curve



### 5.2 Key Performance Test

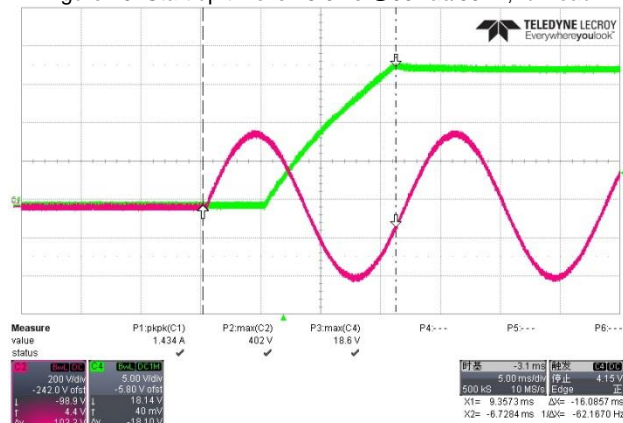
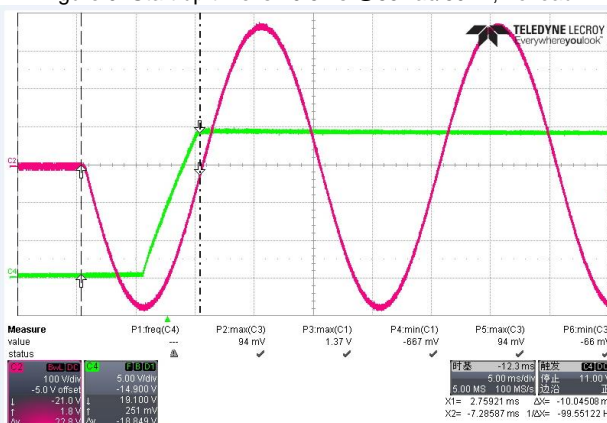
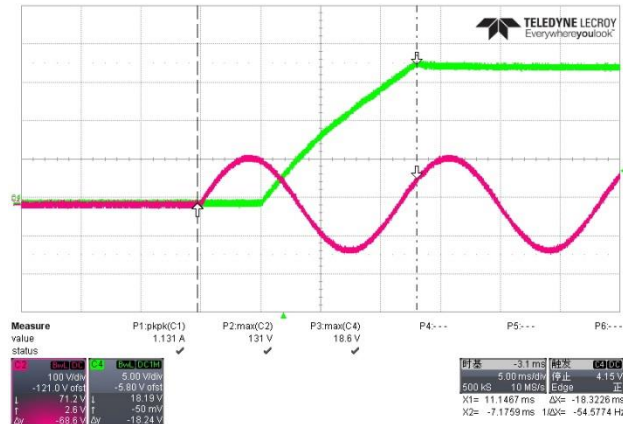
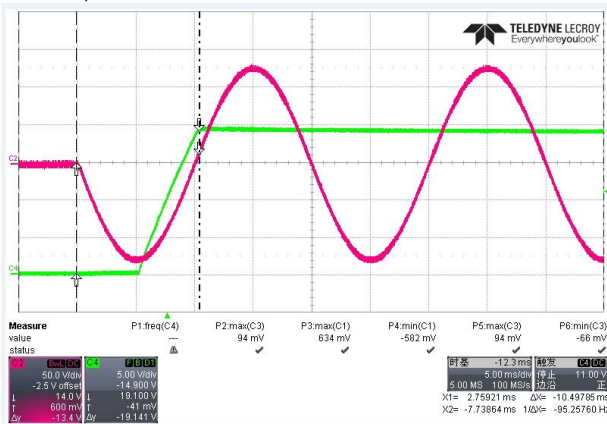
#### 5.2.1 Start-up Performance

The start-up time is measured with a differential probe across AC inputs, "L" and "N" connectors and a common low-voltage probe across output terminals, "+V" and "GND" connectors. Before starting up, buck capacitors should be discharged.

Table 5: Start-up Performance

| AC input voltage | Loading conditions |           | Figures          |
|------------------|--------------------|-----------|------------------|
|                  | No load            | Full load |                  |
| 85Vac/60Hz       | 10.5ms             | 18.6ms    | Fig. 9, Fig. 10  |
| 115Vac/60Hz      | 10.4ms             | 17.9ms    | -                |
| 230Vac/50Hz      | 10.2ms             | 16.5ms    | -                |
| 265Vac/50Hz      | 10.1ms             | 16.1ms    | Fig. 11, Fig. 12 |

CH2:Vin; CH4:Vo



### 5.2.2 Rise Time

The rise time is measured with a common low-voltage probe across output terminals, “+V” and “GND” connectors. Before starting up, output capacitors should be discharged.

Table 6: Rise Time

| AC input voltage | Loading conditions |           | Figures         |
|------------------|--------------------|-----------|-----------------|
|                  | No load            | Full load |                 |
| 85Vac/60Hz       | 5.3ms              | 12.7ms    | Fig. 13, Fig.14 |
| 115Vac/50Hz      | 5.3ms              | 12.4ms    | -               |
| 230Vac/50Hz      | 5.1ms              | 11.2ms    | -               |
| 265Vac/50Hz      | 5.1ms              | 10.8ms    | Fig. 15, Fig.16 |

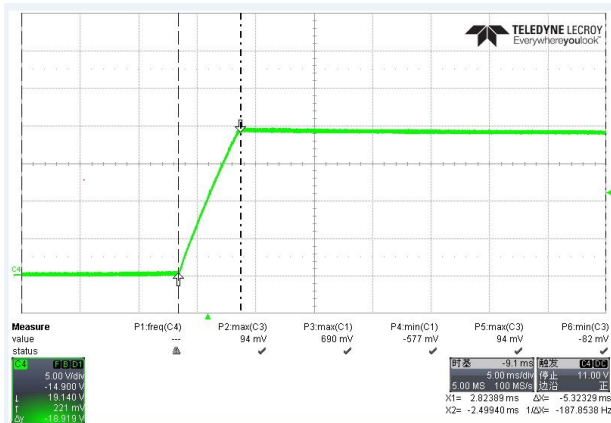


Fig. 13: Rise time is 5.3ms @85Vac/60Hz, no load

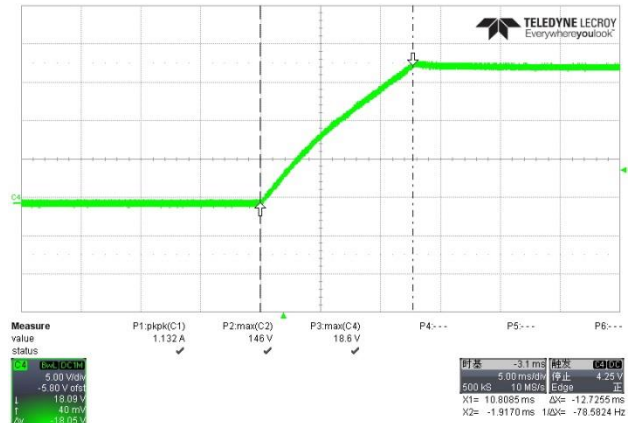


Fig 14: Rise time is 12.7ms @85Vac/60Hz, full load

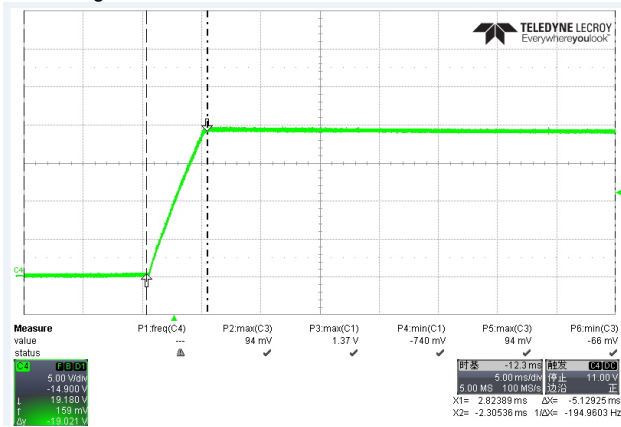


Figure 15: Rise time is 5.1ms @265Vac/50Hz, no load

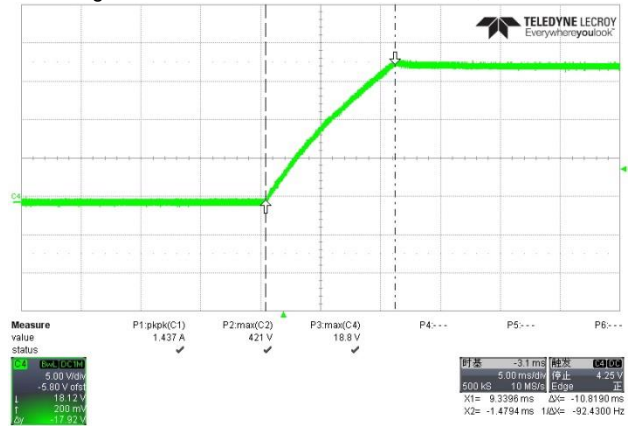


Figure 16: Rise time is 10.8ms @265Vac/50Hz, full load

### 5.2.3 Voltage Stress

The voltage is measured between the “Drain” and “S” pins of AP3928. The test needs differential probes.

Table 7: Internal MOSFET Drain-Source Voltage Stress

| AC input voltage | Loading conditions |           | Figures          |
|------------------|--------------------|-----------|------------------|
|                  | No load            | Full load |                  |
| 85Vac/60Hz       | 139V               | 155V      | Fig. 17, Fig 18  |
| 115Vac/60Hz      | 184V               | 197V      | -                |
| 230Vac/50Hz      | 358V               | 364V      | -                |
| 265Vac/50Hz      | 396V               | 438V      | Fig. 19, Fig. 20 |

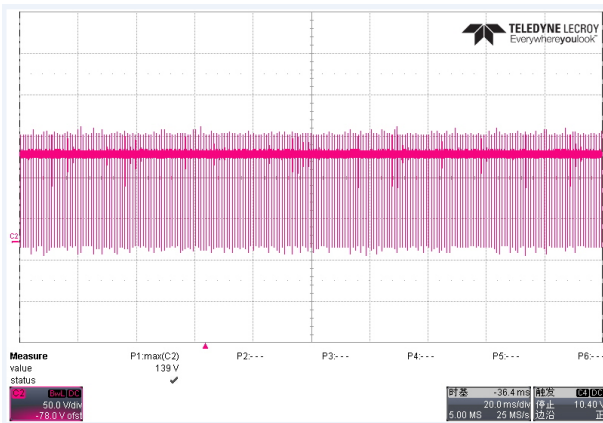


Figure 17: 139V@85Vac/60Hz, no load

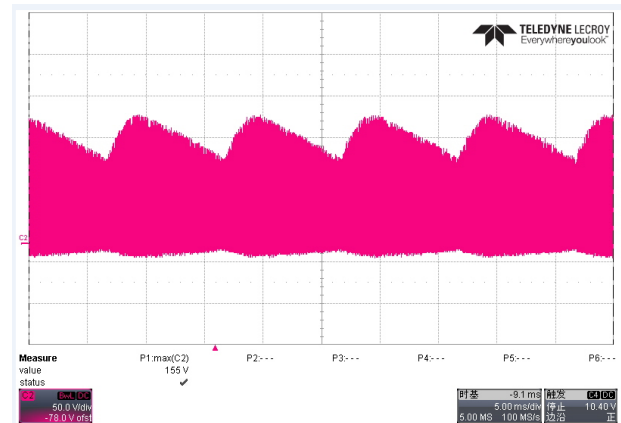


Figure 18: 155V@85Vac/60Hz, full load

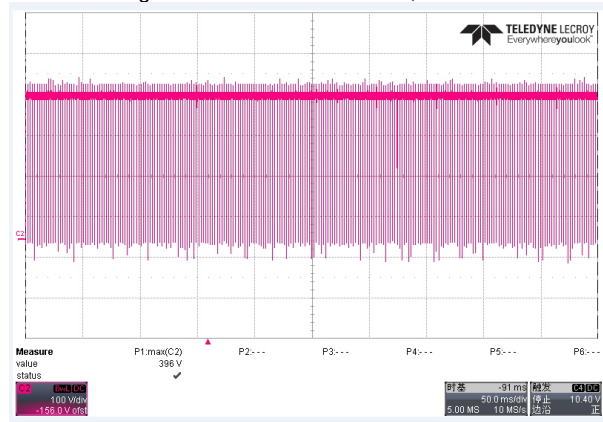


Figure 19: 396V@265Vac/50Hz, no load

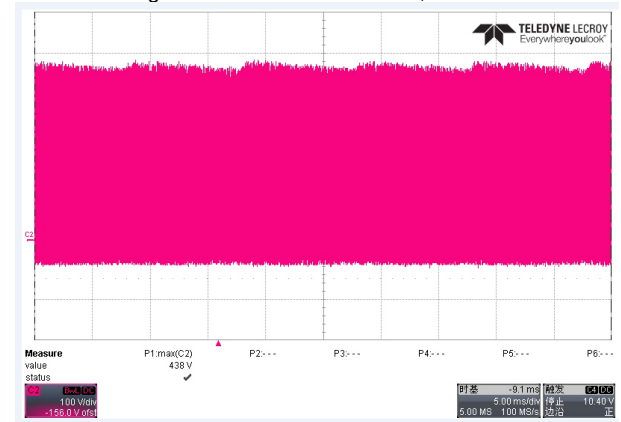


Figure 20: 438V@265Vac/50Hz, full load

### 5.2.4 Output Ripple & Noise

The ripple and noise is tested at PCB terminal, using 10:1 probe without probe cap and ground clip. The bandwidth is limited to 20MHz. A 10 $\mu$ F electrolytic capacitor and a 100nF ceramic capacitor should be paralleled to the output terminal.

Table 8: Ripple & Noise

| AC input voltage | Loading conditions |           | Figures          |
|------------------|--------------------|-----------|------------------|
|                  | No load            | Full load |                  |
| 85Vac/60Hz       | 15.4mV             | 57.6mV    | Fig. 21, Fig.22  |
| 115Vac/60Hz      | 25.5mV             | 56.9mV    | -                |
| 230Vac/50Hz      | 27.8mV             | 55.2mV    | -                |
| 265Vac/50Hz      | 29.7mV             | 55.7mV    | Fig. 23, Fig. 24 |

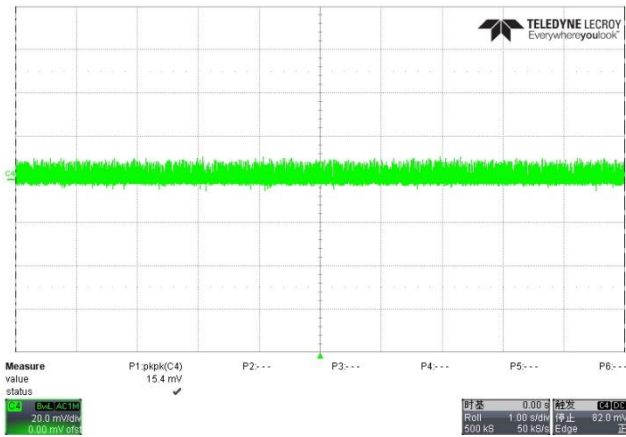


Figure 21: Output R&N, 15.4mV@85Vac/60Hz, no load,

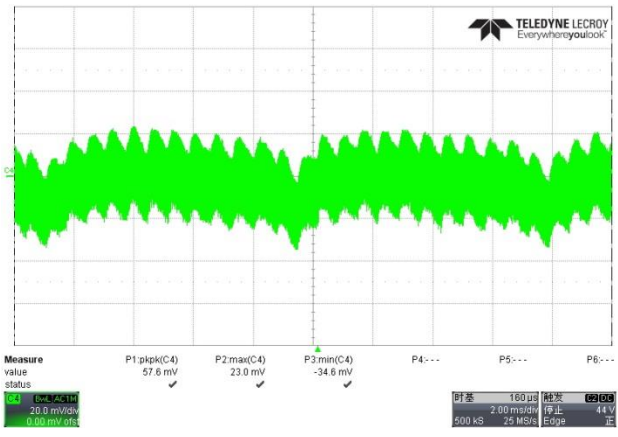


Figure 22: Output R&N, 57.6mV@85Vac/60Hz, full load,

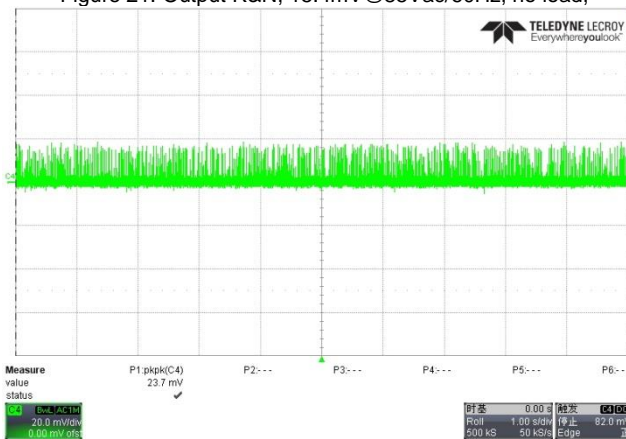


Figure 23: Output R&N, 29.7mV@265Vac/50Hz, no load

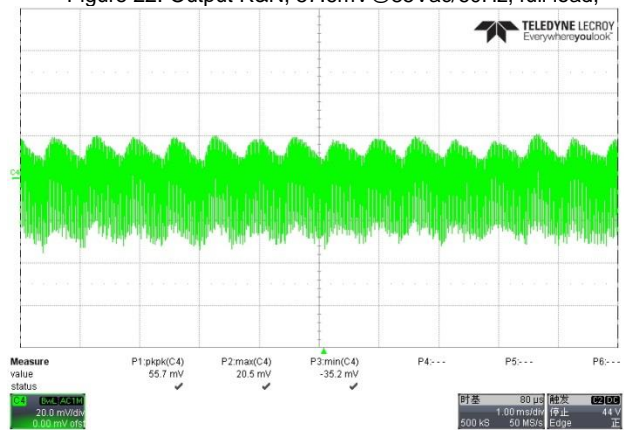


Figure 24: Output R&N, 55.7mV@265Vac/50Hz, full load

### 5.2.5 Dynamic Response

The dynamic response of output voltage is tested at the PCB terminal and the bandwidth is limited to 20MHz. Loading is set 0A as low load and 550mA as high load. Besides, the period is 2 seconds and the ramp is set at 250mA/μs.

Table 9: Dynamic Response

| AC input voltage | Output voltage |           | Figures |
|------------------|----------------|-----------|---------|
|                  | Max Vo(V)      | Min Vo(V) |         |
| 85Vac/60Hz       | 19.1           | 14.5      | Fig. 25 |
| 115Vac/60Hz      | 19.2           | 14.6      | -       |
| 230Vac/50Hz      | 19.4           | 13.9      | -       |
| 265Vac/50Hz      | 19.5           | 13.4      | Fig. 26 |

CH1: Io; CH4: Vo

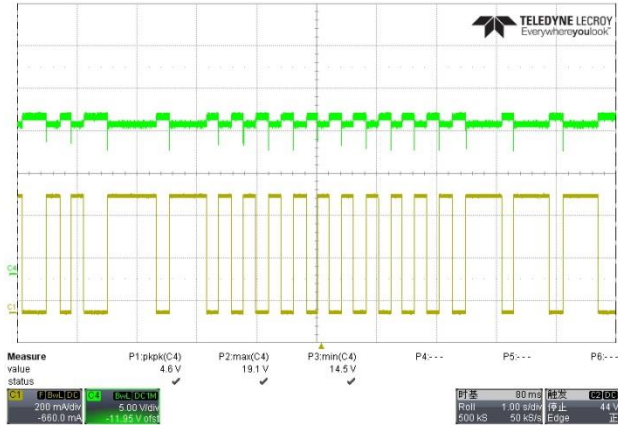


Figure 25: 14.5V~19.1V  
@0~550mA,0.5s, 250mA/μs, 85Vac/60Hz

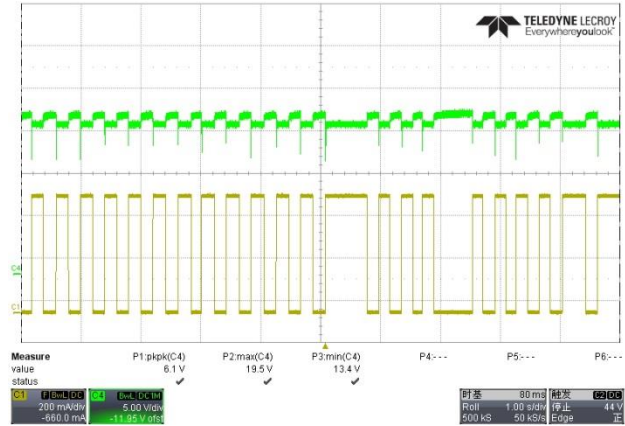


Figure 26: 13.4V~19.5V  
@0~550mA,0.5s, 250mA/μs, 265Vac/50Hz

### 5.3 Protection Test

#### 5.3.1 Short Circuit Protection (SCP) Test

The SCP test is measured under the condition that output cable terminals are shorted. The cable end short resistance value used is 50mΩ.

Table 10: Short Circuit Protection Test

| AC input voltage | Max Vo (mV) | Max Io(mA) | Vds(V) | Average input power (W) | Figures |
|------------------|-------------|------------|--------|-------------------------|---------|
| 85Vac/60Hz       | 320         | 349        | 134    | 0.480                   | Fig. 27 |
| 115Vac/60Hz      | 320         | 364        | 179    | 0.698                   | -       |
| 230Vac/50Hz      | 448         | 694        | 352    | 0.442                   | -       |
| 265Vac/50Hz      | 448         | 777        | 404    | 0.234                   | Fig. 28 |

CH2: Vds; CH3 :Io; CH4: Vo

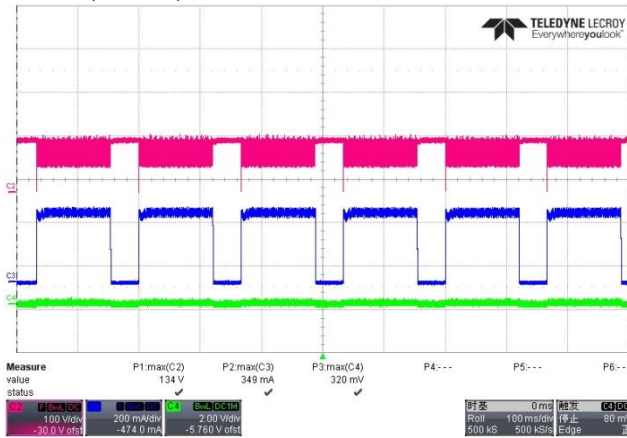


Figure 27: Output current, 349mA; output voltage, 320mV; Vds is 134V@output is shorted@85Vac/60Hz

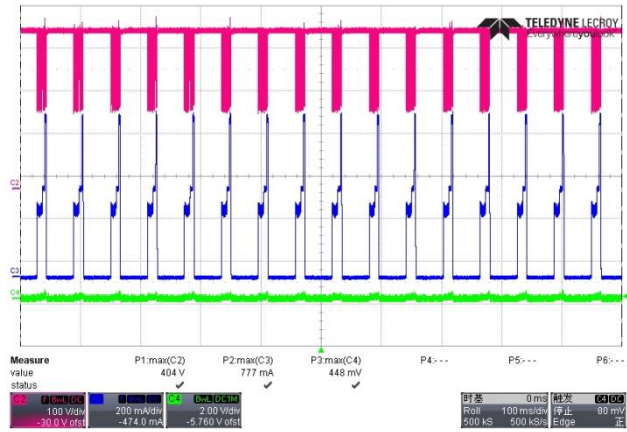


Figure 28: Output current, 777mA; output voltage, 448mV; Vds is 404V@output is shorted@265Vac/50Hz

#### 5.3.2 Open Loop Detection (OLD) Protection Test

The open loop detection protection is measured when FB pin is connected to Source pin.

Table 11: Open Loop Detection Test

| AC input voltage | The peak of output voltage(V) | Figures |
|------------------|-------------------------------|---------|
| 85Vac/60Hz       | 3.01                          | Fig. 29 |
| 115Vac/60Hz      | 3.07                          | -       |
| 230Vac/50Hz      | 3.20                          | -       |
| 265Vac/50Hz      | 3.20                          | Fig. 30 |

CH2: Vds; CH3 :Io; CH4 :Vo

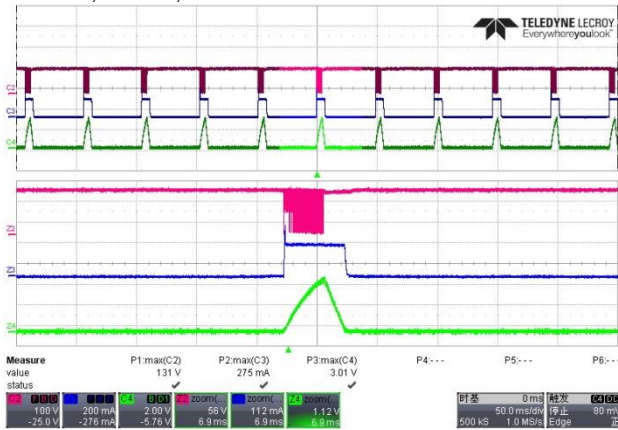


Fig. 29: Output voltage 3.01V@OLD, 85Vac/60Hz, full load

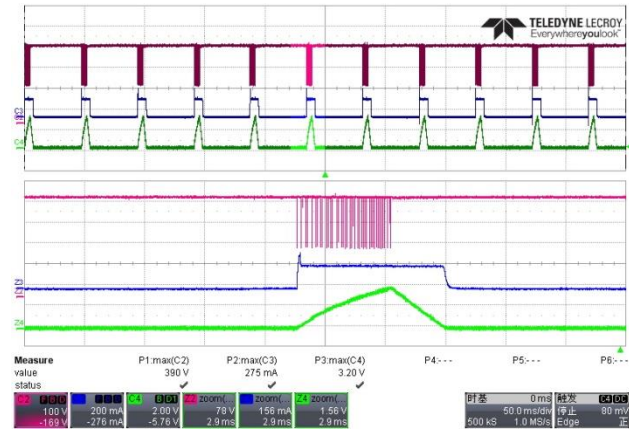


Fig. 30: Output voltage 3.20V@OLD, 265Vac/50Hz, full load

### 5.3.3 Overload Protection (OLP) Test

The overload protection point is tested as below: increase the loading by 10mA/step until the system cannot maintain a stable output, and then mark the loading level as over load protection point.

Table 12: Overload Protection Point test

| AC input voltage | Overload protection point(mA) |
|------------------|-------------------------------|
| 85Vac/60Hz       | 750                           |
| 115Vac/60Hz      | 750                           |
| 230Vac/50Hz      | 750                           |
| 265Vac/50Hz      | 750                           |

### 5.4 Thermal Test

The thermal test is under ambient temperature after 1-hour aging. The board has no case in open frame. Thermal imager is used to observe the surface temperature of AP3928.

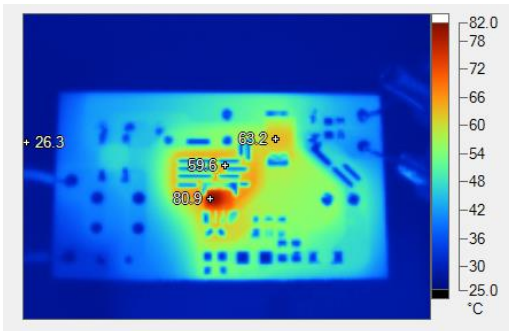


Figure 31: AP3928, 80.9°C, D2 63.2°C @85Vac/60Hz, full load, ambient temperature, 25°C.

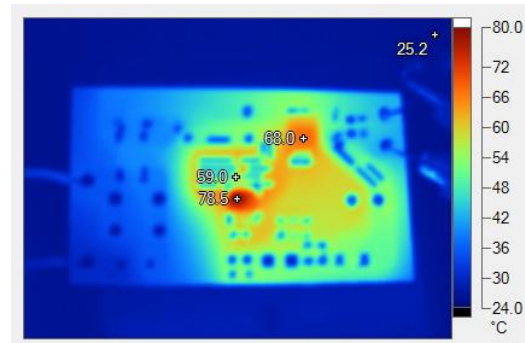


Figure 32: AP3928, 78.5°C, D2 68°C @ 265Vac/50Hz, full load, ambient temperature, 25°C.

## 5.5 System EMI Scan

The power supply meets EN55022 Class B (for 110Vac input and 230Vac input) EMI requirements with more than 6dB margin.

### 5.5.1 Conducted EMI Test of 230V@full load

The test result can pass EN55022 Class B limit with more than 6dB margin.

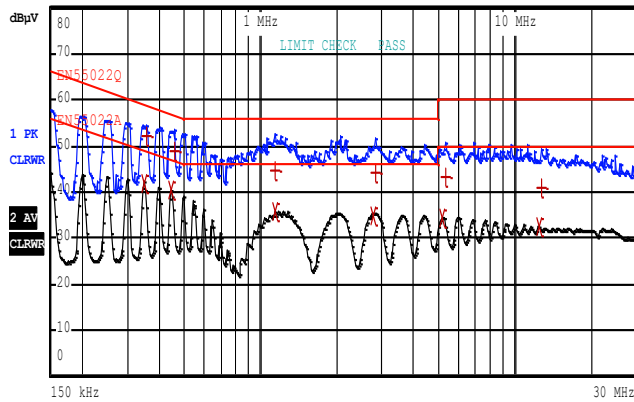


Fig. 33, L line conducted waveform@230Vac/50Hz, full load.

| EDIT PEAK LIST (Final Measurement Results) |                   |            |       |  |
|--|-------------------|------------|-------|--|
| Trace1:                                    | EN55022Q          |            |       |  |
| Trace2:                                    | EN55022A          |            |       |  |
| Trace3:                                    | ---               |            |       |  |
| TRACE                                      | FREQUENCY         | LEVEL dBμV | DELTA |  |
| 2 Average                                  | 346.008411606 kHz | 42.00      | -7.0  |  |
| 1 Quasi Peak                               | 352.963180679 kHz | 52.13      | -6.7  |  |
| 2 Average                                  | 443.732257589 kHz | 40.40      | -6.5  |  |
| 1 Quasi Peak                               | 457.177788726 kHz | 48.98      | -7.7  |  |
| 2 Average                                  | 1.13065507631 MHz | 35.60      | -10.3 |  |
| 1 Quasi Peak                               | 1.14196162708 MHz | 44.82      | -11.1 |  |
| 2 Average                                  | 2.76855896362 MHz | 34.99      | -11.0 |  |
| 1 Quasi Peak                               | 2.82420699879 MHz | 44.41      | -11.5 |  |
| 2 Average                                  | 5.18203480607 MHz | 34.53      | -15.4 |  |
| 1 Quasi Peak                               | 5.33905564273 MHz | 43.29      | -16.7 |  |
| 2 Average                                  | 12.4388782936 MHz | 32.46      | -17.5 |  |
| 1 Quasi Peak                               | 12.6888997473 MHz | 41.04      | -18.9 |  |

Fig. 34, L line conducted data@230Vac/50Hz, full load.

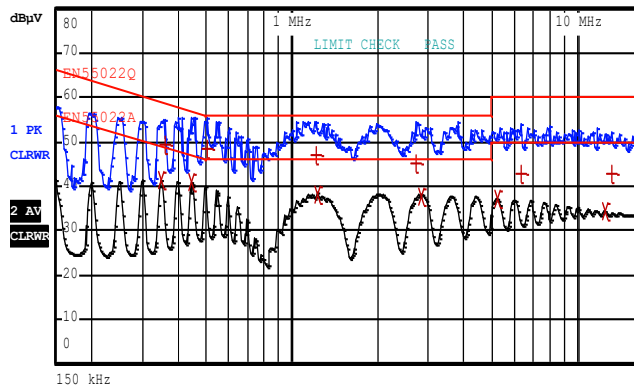


Figure 35: N line conducted waveform@230Vac/50Hz, full load.

| EDIT PEAK LIST (Final Measurement Results) |                   |            |       |  |
|--|-------------------|------------|-------|--|
| Trace1:                                    | EN55022Q          |            |       |  |
| Trace2:                                    | EN55022A          |            |       |  |
| Trace3:                                    | ---               |            |       |  |
| TRACE                                      | FREQUENCY         | LEVEL dBμV | DELTA |  |
| 2 Average                                  | 346.008411606 kHz | 41.41      | -7.0  |  |
| 1 Quasi Peak                               | 356.492812486 kHz | 49.42      | -9.0  |  |
| 2 Average                                  | 443.732257589 kHz | 40.96      | -6.0  |  |
| 1 Quasi Peak                               | 500.008614528 kHz | 48.48      | -7.0  |  |
| 1 Quasi Peak                               | 1.21221527836 MHz | 46.81      | -9.0  |  |
| 2 Average                                  | 1.22433743114 MHz | 38.36      | -7.0  |  |
| 1 Quasi Peak                               | 2.71400741459 MHz | 45.33      | -10.0 |  |
| 2 Average                                  | 2.82420699879 MHz | 37.87      | -8.0  |  |
| 2 Average                                  | 5.23385515413 MHz | 37.17      | -12.0 |  |
| 1 Quasi Peak                               | 6.32306725703 MHz | 42.74      | -17.0 |  |
| 2 Average                                  | 12.4388782936 MHz | 34.19      | -15.0 |  |
| 1 Quasi Peak                               | 13.0733860985 MHz | 42.97      | -17.0 |  |

Figure 36: N line conducted data@230Vac/50Hz, full load.



### 5.5.2 Conducted EMI Test of 110V@full load

The test result can pass EN55022 Class B limit with more than 6dB margin.

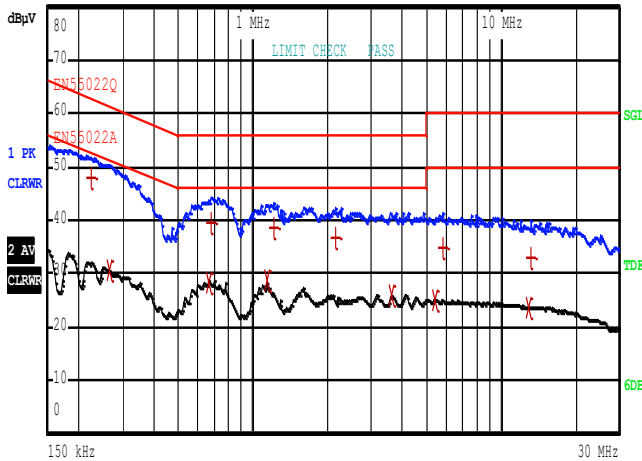


Figure 37: L line conducted waveform@110Vac/60Hz, full load.

| EDIT PEAK LIST (Final Measurement Results) |                   |            |                |
|--|-------------------|------------|----------------|
| Trace1:                                    | EN55022Q          |            |                |
| Trace2:                                    | EN55022A          |            |                |
| Trace3:                                    | ---               |            |                |
| TRACE                                      | FREQUENCY         | LEVEL dBµV | DELTA LIMIT dB |
| 1 Quasi Peak                               | 221.118376275 kHz | 47.97      | -14.80         |
| 2 Average                                  | 264.49018761 kHz  | 30.76      | -20.52         |
| 2 Average                                  | 660.656865747 kHz | 28.35      | -17.64         |
| 1 Quasi Peak                               | 673.936068749 kHz | 39.44      | -16.56         |
| 2 Average                                  | 1.13065507631 MHz | 28.56      | -17.43         |
| 1 Quasi Peak                               | 1.21221527836 MHz | 38.78      | -17.21         |
| 1 Quasi Peak                               | 2.1374603093 MHz  | 36.76      | -19.23         |
| 2 Average                                  | 3.6218534158 MHz  | 25.73      | -20.26         |
| 2 Average                                  | 5.39244619915 MHz | 24.87      | -25.12         |
| 1 Quasi Peak                               | 5.83924652649 MHz | 34.64      | -25.35         |
| 2 Average                                  | 12.8157887448 MHz | 23.83      | -26.16         |
| 1 Quasi Peak                               | 13.0733860985 MHz | 33.12      | -26.87         |

Figure 38: L line conducted data@110Vac/60Hz, full load.

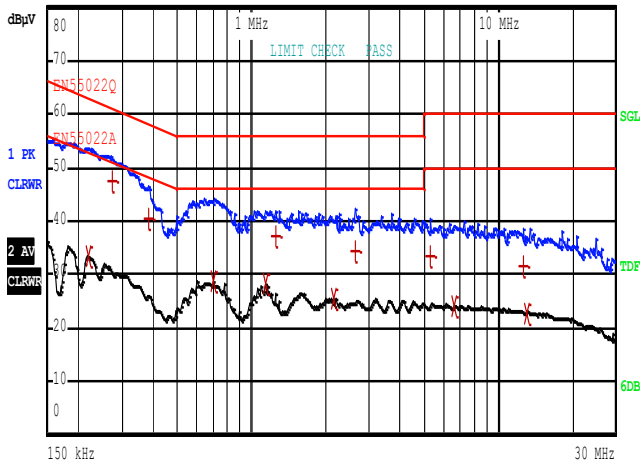


Figure 39: N line conducted waveform@110Vac/60Hz, full load.

| EDIT PEAK LIST (Final Measurement Results) |                   |            |                |
|--|-------------------|------------|----------------|
| Trace1:                                    | EN55022Q          |            |                |
| Trace2:                                    | EN55022A          |            |                |
| Trace3:                                    | ---               |            |                |
| TRACE                                      | FREQUENCY         | LEVEL dBµV | DELTA LIMIT dB |
| 2 Average                                  | 216.761470714 kHz | 33.49      | -19.44         |
| 1 Quasi Peak                               | 272.504504785 kHz | 47.46      | -13.57         |
| 1 Quasi Peak                               | 382.208547038 kHz | 40.61      | -17.61         |
| 2 Average                                  | 694.357005568 kHz | 28.86      | -17.13         |
| 2 Average                                  | 1.13065507631 MHz | 28.30      | -17.69         |
| 1 Quasi Peak                               | 1.2489466135 MHz  | 37.25      | -18.74         |
| 2 Average                                  | 2.1374603093 MHz  | 25.31      | -20.68         |
| 1 Quasi Peak                               | 2.634188858 MHz   | 34.41      | -21.58         |
| 1 Quasi Peak                               | 5.28619370567 MHz | 33.38      | -26.62         |
| 2 Average                                  | 6.57980914316 MHz | 24.15      | -25.84         |
| 1 Quasi Peak                               | 12.5632670765 MHz | 31.55      | -28.44         |
| 2 Average                                  | 12.9439466322 MHz | 22.89      | -27.11         |

Figure 40: N line conducted data@110Vac/60Hz, full load.

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