



User Guide for
FEBFAN6230AMPX_CH04U12A
Evaluation Board

Synchronous Rectification Controller
12.5 W (5 V / 2.5 A) Power Supply
Using FAN6230A

Featured Fairchild Products:

FAN501

FAN6230A

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This user guide supports the evaluation kit for the FAN6230A. It should be used in conjunction with the FAN6230A datasheet as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at <http://www.fairchildsemi.com>.

1. Introduction

This document is an engineering report describing measured performance of the FAN6230A evaluation board.

1.1. General Description

The FAN6230A is a controller that improves efficiency in secondary-side Synchronous Rectifier (SR) MOSFETs. An internal shunt regulator with low bias current and an internal charge pump circuit reduce external part counts, total cost, and system power consumption. Adoption of the internal charge pump circuit allows the FAN6230A to work very well under low bias voltage conditions with good Constant Current (CC) regulation without a rectifier diode.

FAN6230A also features adjustable cable compensation for precise constant voltage regulations at the cable end.

Unlike the traditional method of measuring the SR MOSFET drain-to-source voltage to sense the current, which is sensitive to the noise introduced by poor PCB layout, the FAN6230A uses innovative Linear-Prediction Timing Control (LPC) to estimate the SR MOSFET turn-on time without additional current-sensing circuitry.

In Green Mode, the FAN6230A shuts off the SR MOSFETs, which lowers bias current down to 500 μ A, so the total power consumption of the system is further reduced.

1.2. Features

- Secondary-Side SR Controller for Flyback Converters
- Smooth Operation in DCM and CCM
- Integrated Shunt Regulator
- Integrated Charge Pump Circuit for CC Region
- Output Cable Compensation Circuit
- Green-Mode Improves Light-Load Efficiency and No-Load Power Consumption
- PWM Frequency Tracking Using Secondary-Side Winding Voltage
- Ultra Low V_{DD} Operating Voltage for 5 V Output Applications
- Ultra-Low Green-Mode Operating Current (0.5 mA, Typical)
- 16-Pin MLP33 Package
- Advanced Protections
 - RES Dropping Protection (Disable Gate Drive)
 - Over-Temperature Protection (Auto-Restart)

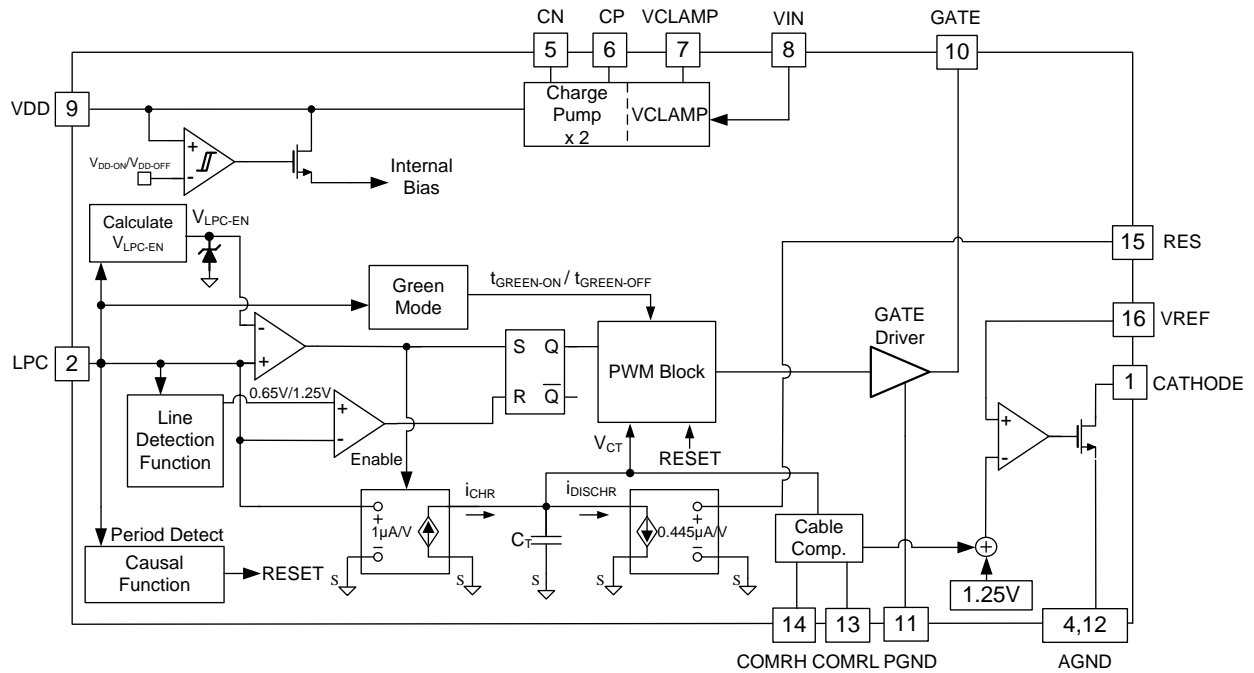


Figure 1. Internal Block Diagram

2. Evaluation Board Specifications

All data for this table was measured at an ambient temperature of 25°C

Table 1. Evaluation Board Specifications

| Fairchild Devices | FAN501 + FAN6230A |
|----------------------------|--------------------------|
| Input Voltage Range | 85 ~ 264 V _{AC} |
| Frequency | 60 / 50 Hz |
| Maximum Output Power | 12.5 W |
| Output Full-Load Condition | 5 V / 2.5 A |

3. Photographs

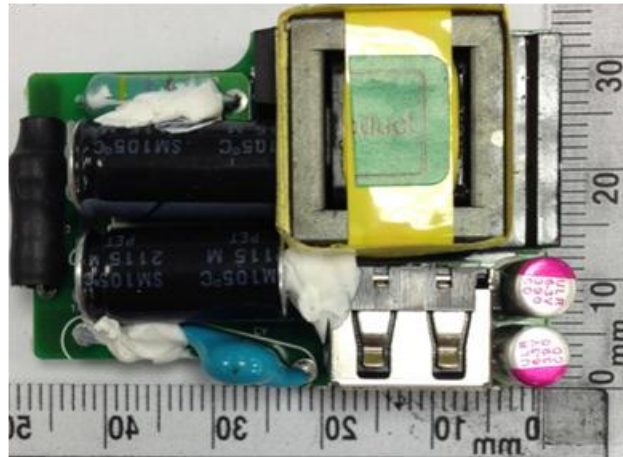


Figure 2. Top View (Dimension 45 x 32 [mm²])

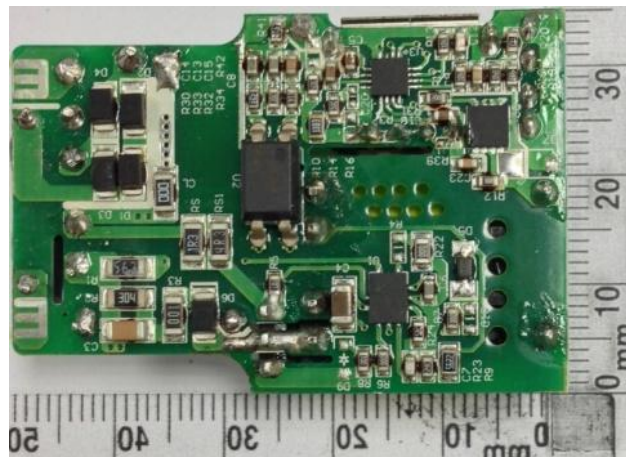


Figure 3. Bottom View (Dimension 45 x 32 [mm²])

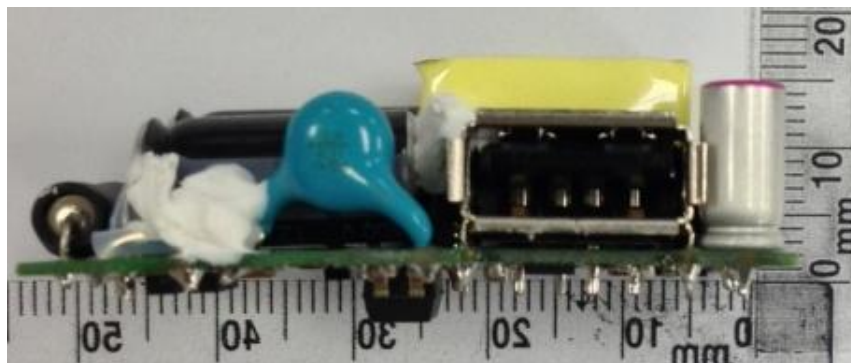


Figure 4. Flank View (Dimension 15 x 45 [mm²])

4. Printed Circuit Board

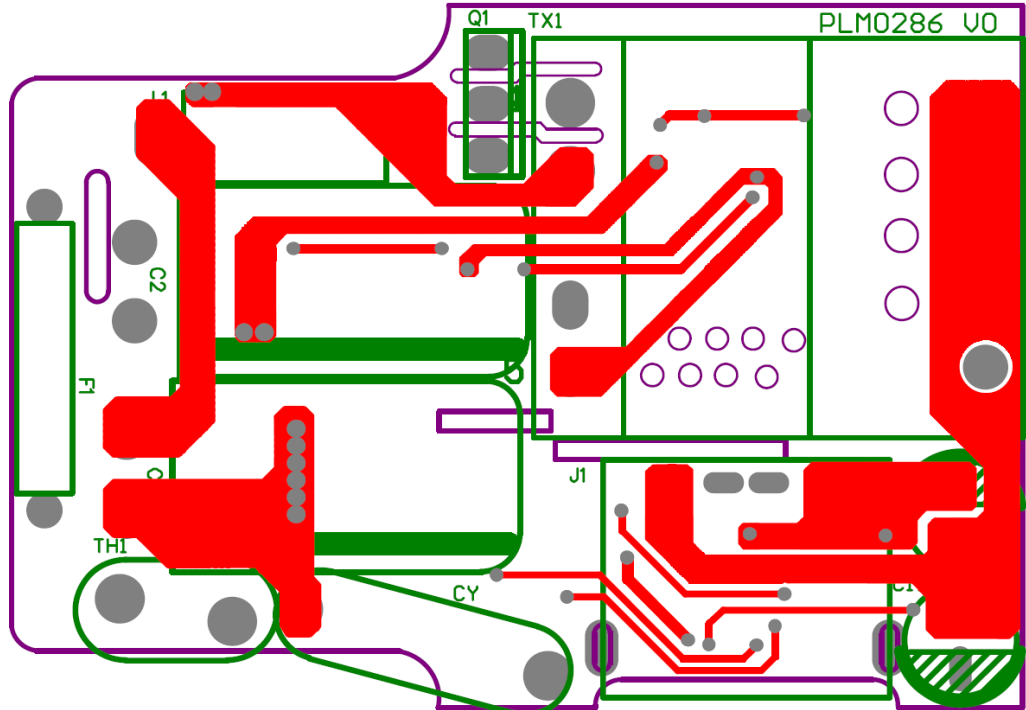


Figure 5. Top Side

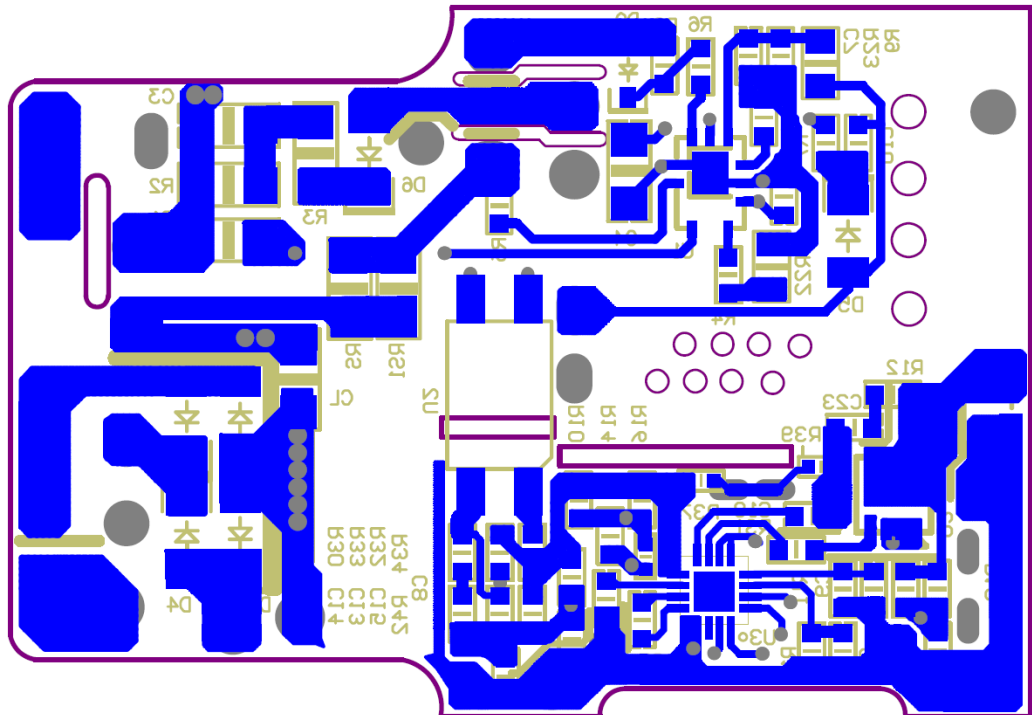


Figure 6. Bottom Side

5. Schematic

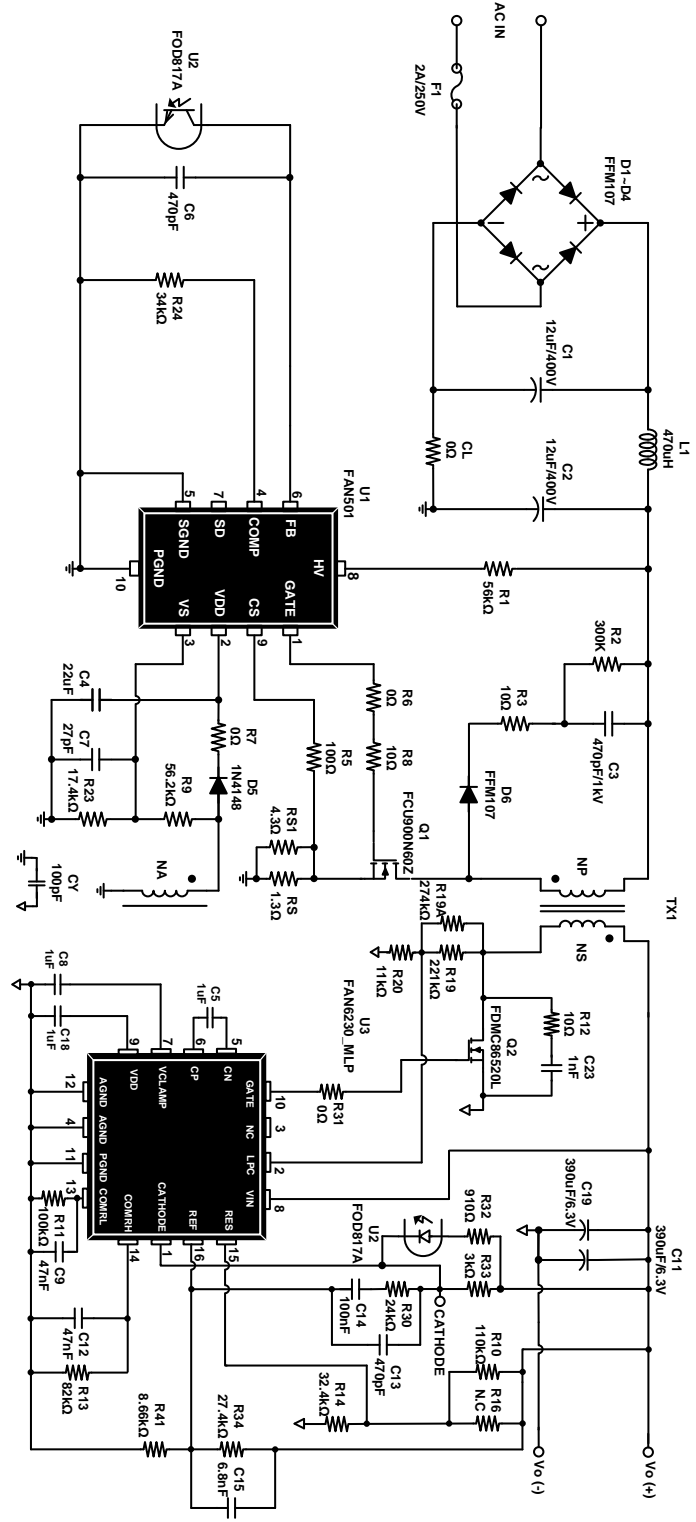


Figure 7. Schematic



6. Bill of Materials

| Component | Part No. | Manufacturer | Qty. | Reference |
|---|---|--------------|------|-------------|
| JUMPER WIRE 0.8 ψ (mm) | | | 1 | TH1 |
| SMD Resistor 0603 0 Ω $\pm 5\%$ | | | 2 | R6, R7 |
| SMD Resistor 0603 10 Ω $\pm 5\%$ | | | 2 | R8, R12 |
| SMD Resistor 0603 100 Ω $\pm 5\%$ | | | 1 | R5 |
| SMD Resistor 0603 100 k Ω $\pm 5\%$ | | | 1 | R11 |
| SMD Resistor 0603 82 k Ω $\pm 5\%$ | | | 1 | R13 |
| SMD Resistor 0603 11 k Ω $\pm 1\%$ | | | 1 | R20 |
| SMD Resistor 0603 17 k 4 Ω $\pm 1\%$ | | | 1 | R23 |
| SMD Resistor 0603 20 Ω $\pm 5\%$ | | | 1 | R31 |
| SMD Resistor 0603 110 k Ω $\pm 5\%$ | | | 1 | R10 |
| SMD Resistor 0603 221 k Ω $\pm 1\%$ | | | 1 | R19 |
| SMD Resistor 0603 24 k Ω $\pm 1\%$ | | | 1 | R30 |
| SMD Resistor 0603 27 k 4 Ω $\pm 1\%$ | | | 1 | R34 |
| SMD Resistor 0603 274 k Ω $\pm 1\%$ | | | 1 | R19A |
| SMD Resistor 0603 3 k Ω $\pm 1\%$ | | | 1 | R33 |
| SMD Resistor 0603 32 k 4 Ω $\pm 1\%$ | | | 1 | R14 |
| SMD Resistor 0603 34 k Ω $\pm 1\%$ | | | 1 | R24 |
| SMD Resistor 0603 8 k 66 Ω $\pm 1\%$ | | | 1 | R41 |
| SMD Resistor 0603 910 Ω $\pm 5\%$ | | | 1 | R32 |
| SMD Resistor 0805 0 Ω $\pm 5\%$ | | | 1 | R22 |
| SMD Resistor 0805 56 k 2 Ω $\pm 1\%$ | | | 1 | R9 |
| SMD Resistor 1206 0 Ω $\pm 5\%$ | | | 1 | CL |
| SMD Resistor 1206 10 Ω $\pm 5\%$ | | | 1 | R3 |
| SMD Resistor 1206 1 Ω 3 $\pm 5\%$ | | | 1 | RS |
| SMD Resistor 1206 300 k Ω $\pm 5\%$ | | | 1 | R2 |
| SMD Resistor 1206 4 Ω 3 $\pm 5\%$ | | | 1 | RS1 |
| SMD Resistor 1206 56 k Ω $\pm 5\%$ | | | 1 | R1 |
| 0603 X7R $\pm 10\%$ 0.1 μ F 50 V | | | 1 | C14 |
| 0603 X7R $\pm 10\%$ 102 pF 50 V | | | 1 | C23 |
| SMD 0603 105P 25 V +80/-20% | | | 3 | C5, C8, C18 |
| 0603 X7R $\pm 10\%$ 27 pF 50 V | | | 1 | C7 |
| 0603 X7R $\pm 10\%$ 471 pF 50 V | | | 2 | C6, C13 |
| 0603 X7R $\pm 10\%$ 473 pF 50 V | | | 2 | C9, C12 |
| 0603 X7R $\pm 10\%$ 682 pF 50 V | | | 1 | C15 |
| 1206 X5R $\pm 10\%$ 22 μ F 10 V | | | 1 | C4 |
| 1206 X7R $\pm 10\%$ 471 pF 1 kV | | | 1 | C3 |
| Electrolytic Capacitor 12 μ F 400 V 105°C | 8*16.5 mm, G-Luxon, GSM126M400T2H5G160 | | 2 | C1, C2 |
| Capacitor 390 μ F 6.3 V 105°C | 5*9 mm, ULR Type, ULR397M0JD09RR | OS-CON | 2 | C11, C19 |



Bill of Materials (continued)

| Component | Part No. | Manufacturer | Qty. | Reference |
|----------------------------------|--------------------------------|--------------|------|--------------------|
| Y1 Capacitor 100P 250 V ±20% | D7x7x9.5 mm | | 1 | CY |
| Fixed Inductor 470 µH ±10% | EC0410-471K | | 1 | L1 |
| Transformer EEH1710 | PN:14315-T001 | SUMIDA | 1 | TX1 |
| SMD Diode 1N4148WS | 1 A / 100 V SOD-323 | Fairchild | 1 | D5 |
| SMD Diode FFM107-M | 1 A / 1000 V SOD-123 | | 5 | D1, D2, D3, D4, D6 |
| SMD MOS FDMC86520L | 60 V 22 A Power33 | Fairchild | 1 | Q2 |
| MOS FCU900N60 Z | 9 A / 600 V TO-251 | Fairchild | 1 | Q1 |
| FOD817AS SMD | SMDIP-B 4 Pin | Fairchild | 1 | U2 |
| SMD IC FAN6230AMPX | MLP | Fairchild | 1 | U3 |
| SMD IC FAN501MPX | MLP | Fairchild | 1 | U1 |
| FUSE GLASS 250 V / 2 A Fast Blow | 3.6•10 mm 36FG(L)R | | 1 | F1 |
| USB JC0010 4411-02004L | Short Type 10•13 mm | | 1 | J1 |
| Teflon Tube | 17 L x 305 m | | 3 | TH1, C1, C2 |
| MCH0223 | Heat-Shrinkable Sleeve 6C15 | | 1 | H1 |
| PCB PLM0286 REV0 | For FAN501MPX 12.5 W | | 1 | |

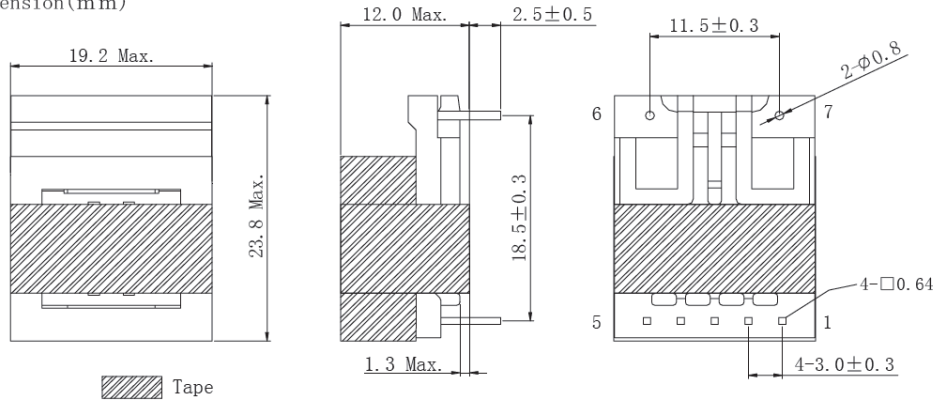
7. Transformer and Winding Specifications

Specification

| |
|-----------------|
| Type EEH1710 |
|-----------------|

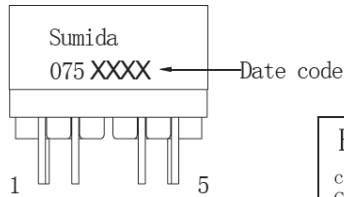
1. Scope and general stipulations.
Ref. to S-074-1511.

2. Appearance
2-1. Dimension(mm)



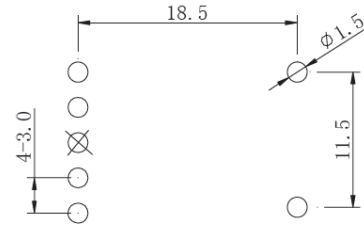
- * Terminals should be measured excluding the length of the soldered point.
- * Dimensions without tolerance approx.
- * Pin3 cut off after soldering.

2-2. Stamp



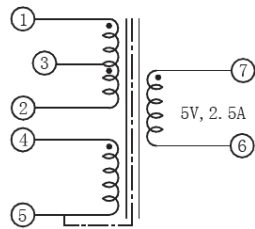
| |
|---|
| <p>RoHS compliance Cd:Max.0.01wt% others:Max.0.1wt%</p> |
|---|

2-3. Recommended land patterns (mm)



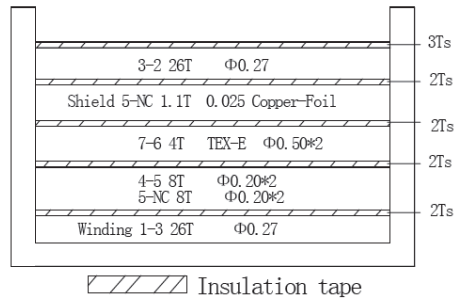
3. Coil specification

3-1. Connection (Bottom view)



* Dots indicate the polarity.

3-2. Diagram(winding stack)



| | |
|--------|--------------------|
| Note : | Spec. No. |
| | S-0716-5978 2/4 |



Specification

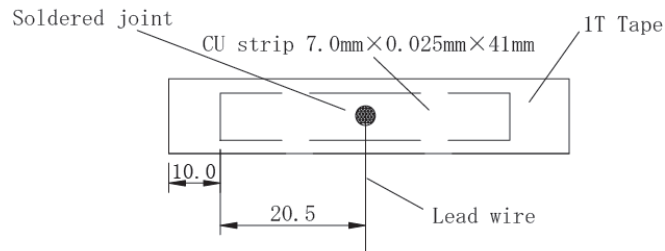
| |
|-----------------|
| Type EEH1710 |
|-----------------|

3-3. Electrical characteristics (at 25°C, unless otherwise specified)

| Item | Specification | Measuring conditions |
|--------------------------|-----------------------|----------------------------|
| Inductance (1-2) | 470 μ H \pm 20% | 100kHz, 1.0V |
| Leakage inductance (1-2) | 30 μ H Max. | 100kHz, 1.0V, tie(4+5+6+7) |
| D. C. R. (1-2) | 650.0 m Ω Max. | |
| D. C. R. (4-5) | 90.0 m Ω Max. | |
| D. C. R. (6-7) | 15m Ω Max. | |
| Hi-pot (1, 2, 4, 5-6, 7) | AC 3000Vrms | 0.5mA, 50Hz, 1minute |
| Hi-pot (1, 2, 6, 7-core) | AC 1500Vrms | 0.5mA, 50Hz, 1minute |

* Testing equipment HP-4284A or equivalent.

4. Copper foil preparation (unit: mm)



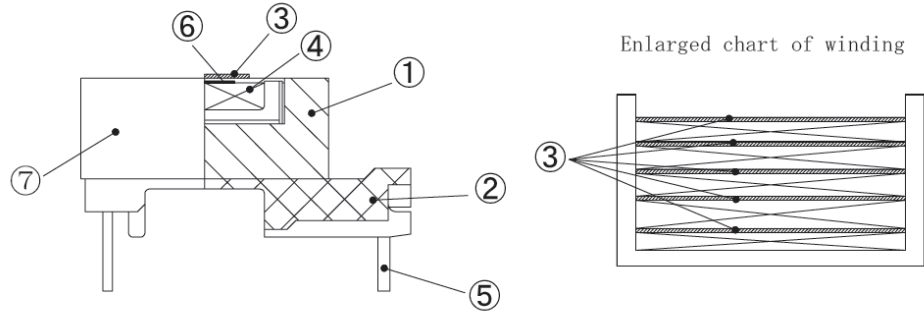
| | |
|--------|---------------------------------|
| Note : | Spec. No. S-0716-5978 3/4 |
|--------|---------------------------------|



Specification

Type
EEH1710

5. Construction and material list



| No. | Components | Materials | Manufacture factory | UL file No. |
|-----|-----------------|---|--|-------------------|
| ① | Core | Ferrite core HE6 or TP4A or equivalent | HPC or TDG etc. | N/A |
| ② | Base | Phenolic Resin PM-9820 | SUMITOMO BAKELITE CO., LTD (LIANCHENG METALS DELECTRONIC FACTORY) | E41429 |
| ③ | Insulation tape | Polyester film No. CT-280 or No. SC1318 or equivalent | YAHUA 3M COMPANY etc. | E165111 E17385 |
| ④ | Wire | Copper Wire MW80C or MW79C or equivalent | JUNG SHING WIRE CO., LTD HOI LUEW etc. | E174837 |
| | | Trip Insulation wire 0.5mm TEX-E | FURUKAWA ELECTRIC CO., LTD | E206440 |
| ⑤ | Pin | HCP | WELL FORE | N/A |
| ⑥ | Copper foil | W=7.0mm T=0.025mm | VARIOUS | N/A |
| ⑦ | Varnish | BC-1346-A | JOHN C. DOLPH COMPANY | E317427 |
| | | WP-2952F-2G | HITACHI CHEMICAL CO., LTD | E72979 |

6. Note

* Storage temperature range : -40°C ~ +85°C

* Operating temperature range : -40°C ~ +85°C (Including coil's self temperature rise)

| | |
|--------|---------------------------------|
| Note : | Spec. No. S-0716-5978 4/4 |
|--------|---------------------------------|





8. Test Conditions & Test Equipment

| | |
|-------------------------|--|
| Evaluation Board | FEBFAN6230AMPX_CH04U12A |
| Test Date | December 16, 2014 |
| Test Equipment | AC Source: 6800 Series Electronic Load: Chroma 63030 Oscilloscope: LeCroy 24Xs-A Power Meter: Yokogawa WT210 |
| Test Items | <ol style="list-style-type: none">1. Standby Power Consumption2. CV (Constant Voltage) Regulation3. CC (Constant Current) Regulation4. Efficiency Test Result5. Output Ripple and Noise6. Normal Operation7. Turn-On Rising8. Brownout Test9. $V_{DD_1st\&2st}$ Voltage Level10. Maximum Power Level11. Output Short Protection12. Dynamic Response13. Voltage Stress of Drain_$1st\&2st$14. Conducted EMI Measurement |

9. Performance of Evaluation Board

9.1. Standby Power Consumption

Table 2. Standby Power Consumption at No-Load Condition

| V_{IN} | 85 V | 115 V | 230 V | 264 V |
|----------|---------|---------|---------|---------|
| No Load | 15.7 mW | 14.9 mW | 18.7 mW | 19.3 mW |

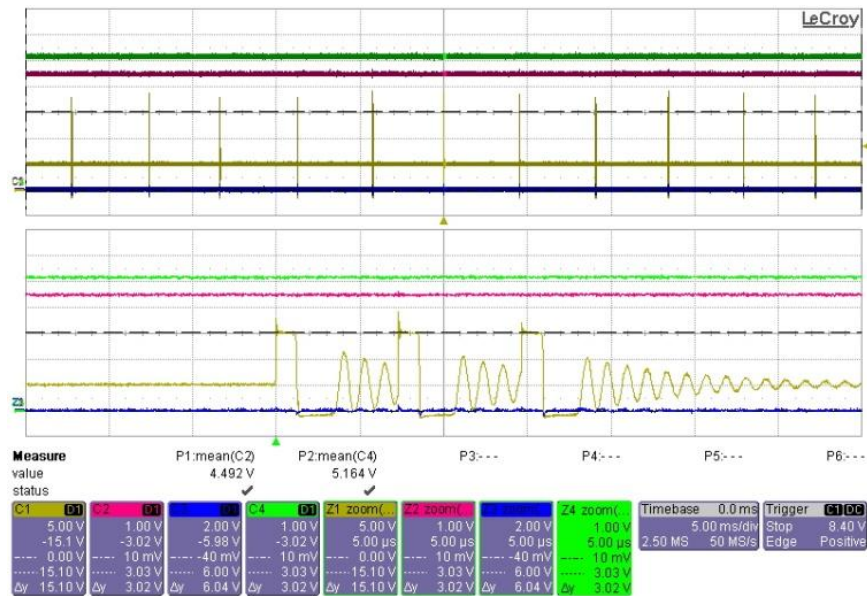


Figure 8. Entry Green Mode, No SR Gate Enable, No Load, 85 V_{AC}, Full-Load (CH1: DET, CH2: SR V_{DD}, CH3: SR Gate, CH4: V_{OUT})

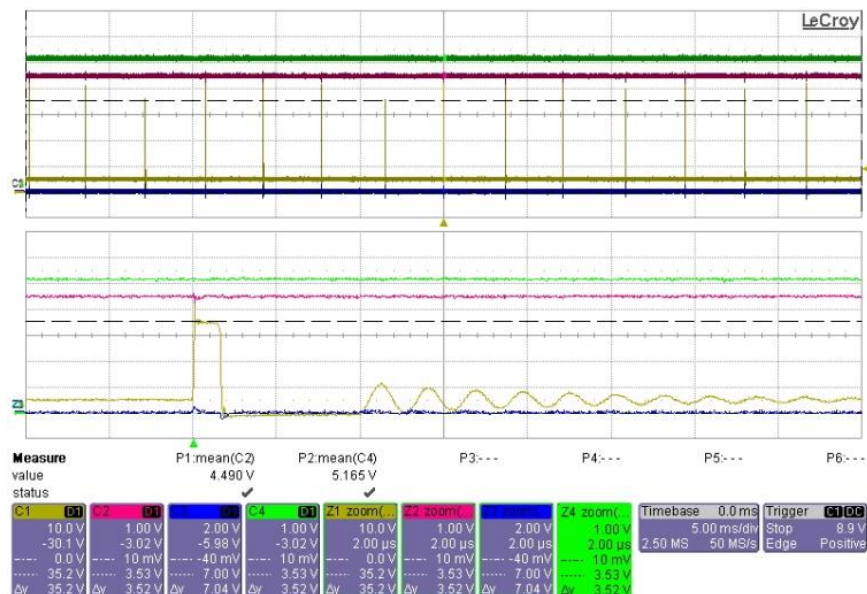


Figure 9. Entry Green Mode, No SR Gate Enable, No Load, 264 V_{AC}, Full-Load (CH1: DET, CH2: SR V_{DD}, CH3: SR Gate, CH4: V_{OUT})



9.2. Constant Voltage (CV) Regulation

Table 3. CV Regulation Enable COMR

| | Max. | Min. | Reg. |
|-------------------|---------|---------|-------|
| With USB Cable | 5.285 V | 5.116 V | 1.68% |
| Without USB Cable | 5.806 V | 5.191 V | 6.15% |

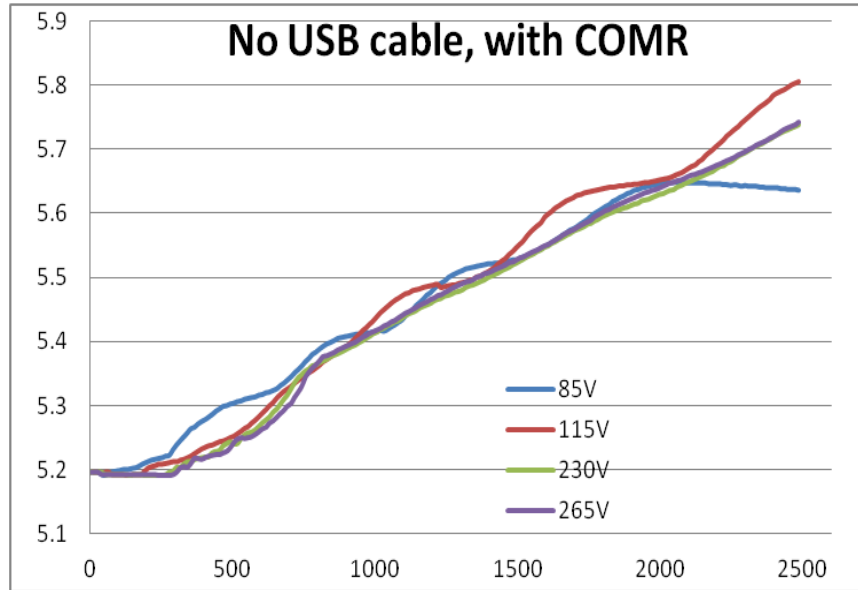


Figure 10. Enable COMR, CV Curve Measure, End of Board

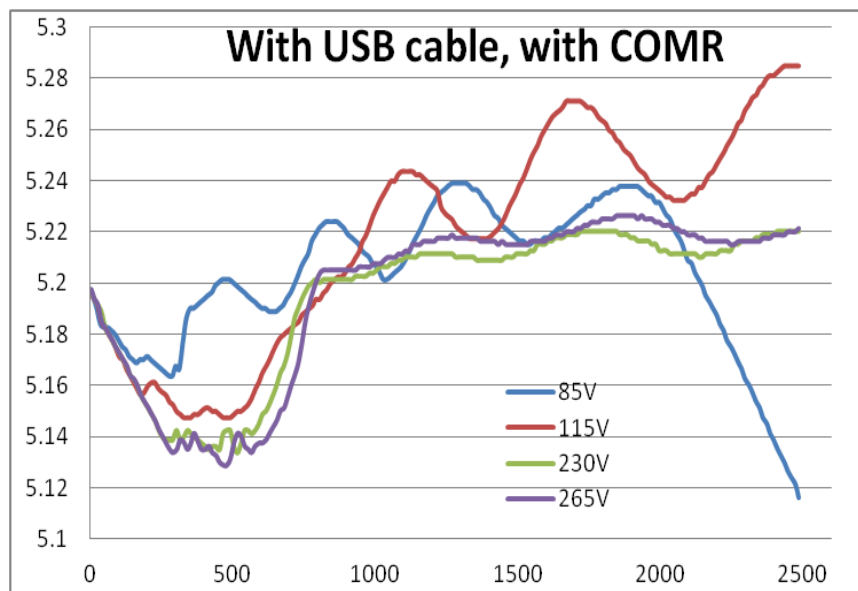


Figure 11. Enable COMR, CV Curve Measure, End of Cable

9.3. Constant Current (CC) Regulation

Table 4. CC Regulation Enable COMR

| | Max. | Min. | Reg. |
|----------------|--------|--------|-------|
| With USB Cable | 2.75 A | 2.48 A | 5.41% |

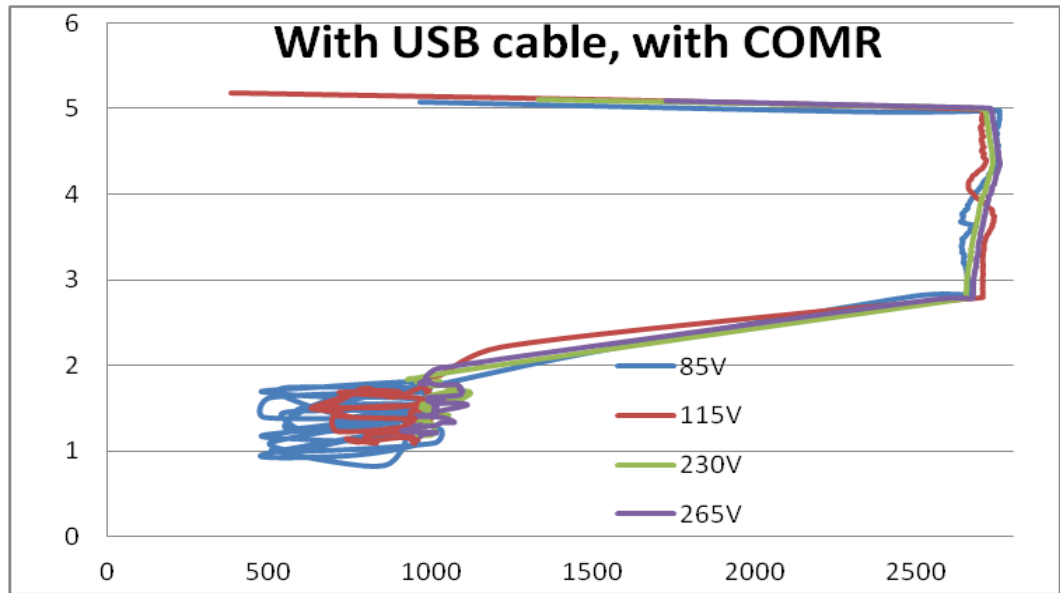


Figure 12. Enable COMR, CC Curve Measure in End of Cable

9.4. Efficiency Test Result

Table 5. Efficiency Test Results, Including 10% of Efficiency

| V_{IN} | 10% | 25% | 50% | 75% | 100% | Avg. |
|----------------------|--------|--------|--------|--------|--------|--------|
| 85 V_{IN} / 60 Hz | 77.63% | 84.73% | 87.27% | 87.82% | 87.10% | 86.73% |
| 115 V_{IN} / 60 Hz | 77.44% | 85.58% | 86.95% | 88.10% | 88.73% | 87.34% |
| 230 V_{IN} / 50 Hz | 72.26% | 80.25% | 86.55% | 88.04% | 88.64% | 85.87% |
| 264 V_{IN} / 50 Hz | 71.02% | 80.11% | 85.46% | 87.25% | 88.22% | 85.26% |

Test Method:

- Test after 15 minutes aging
 - Test from heavy load to light load

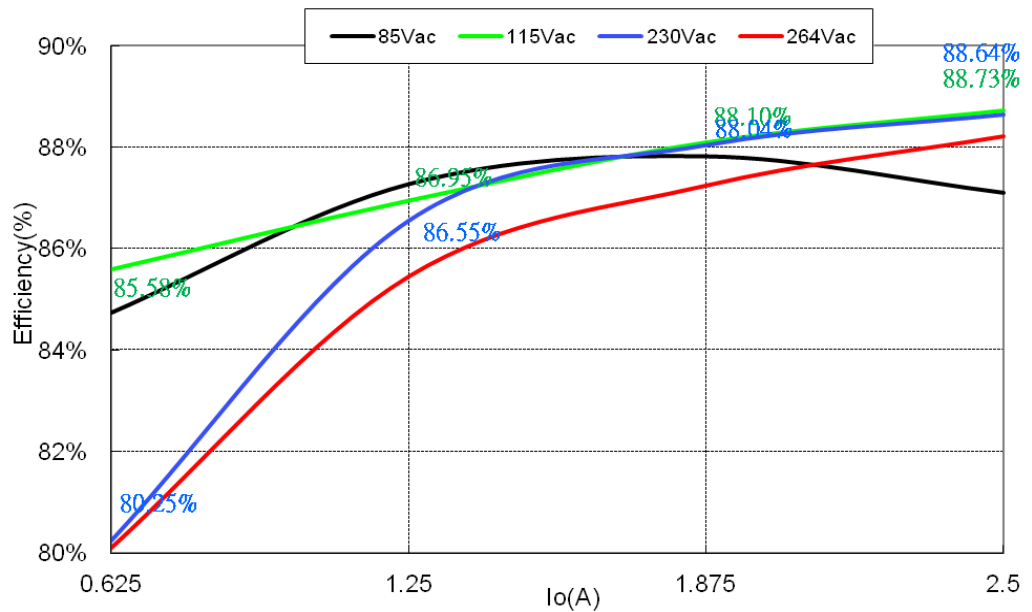


Figure 13. Efficiency vs. Output Load and Input Voltage

9.5. Output Ripple and Noise

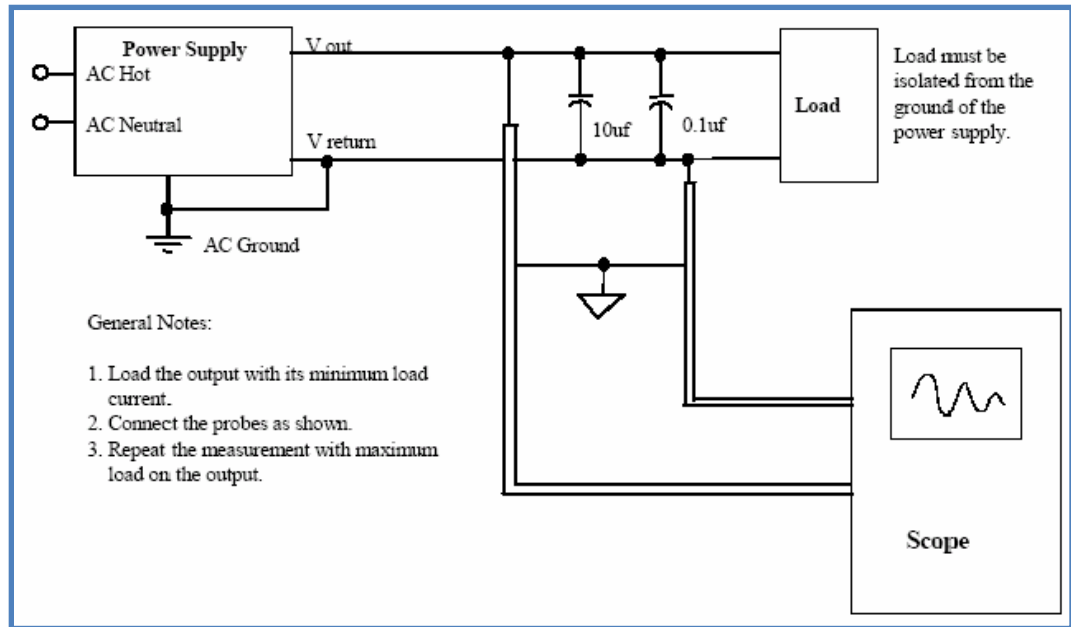


Figure 14. Recommended Test Setup

Table 6. Maximum Output Ripple, End of Board

| V _{IN} | 85 V | 115 V | 230 V | 264 V |
|-----------------------|--------|--------|--------|--------|
| V _{pp(Max.)} | 125 mV | 105 mV | 117 mV | 115 mV |

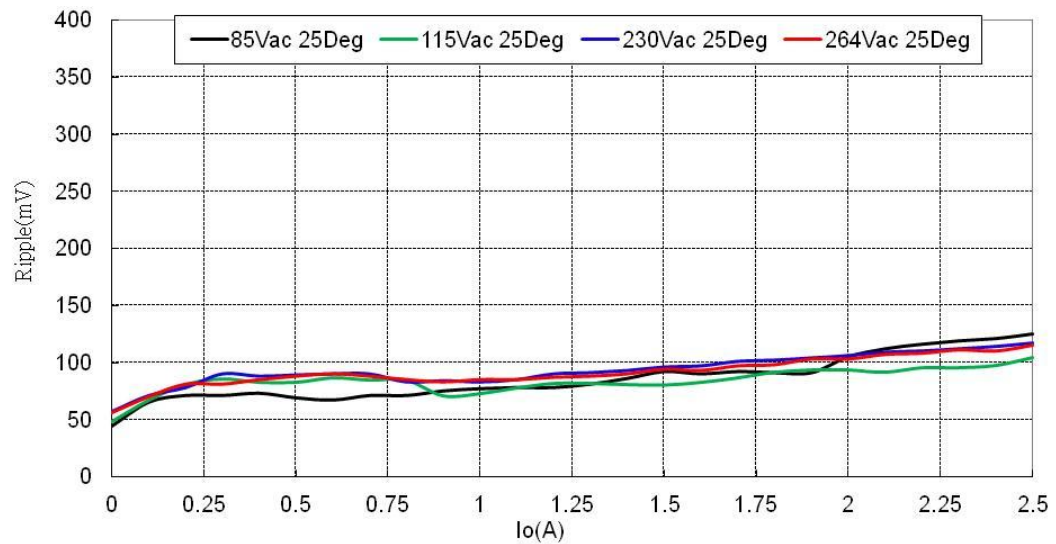


Figure 15. Ripple vs. Output Current and Input Voltage

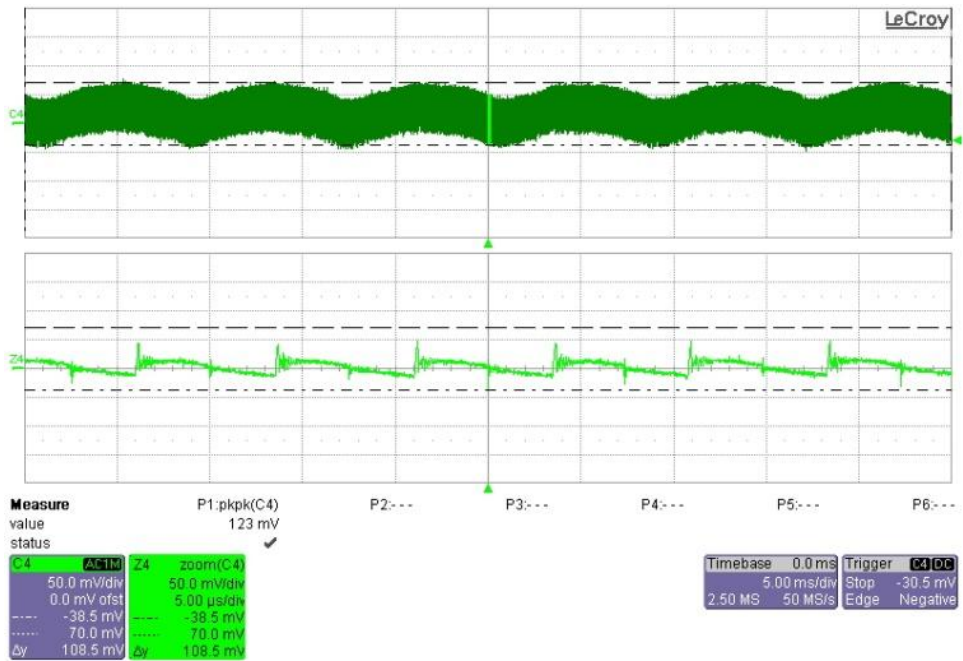


Figure 16. 85 V_{AC}, Full-Load (CH4: V_{OUT})

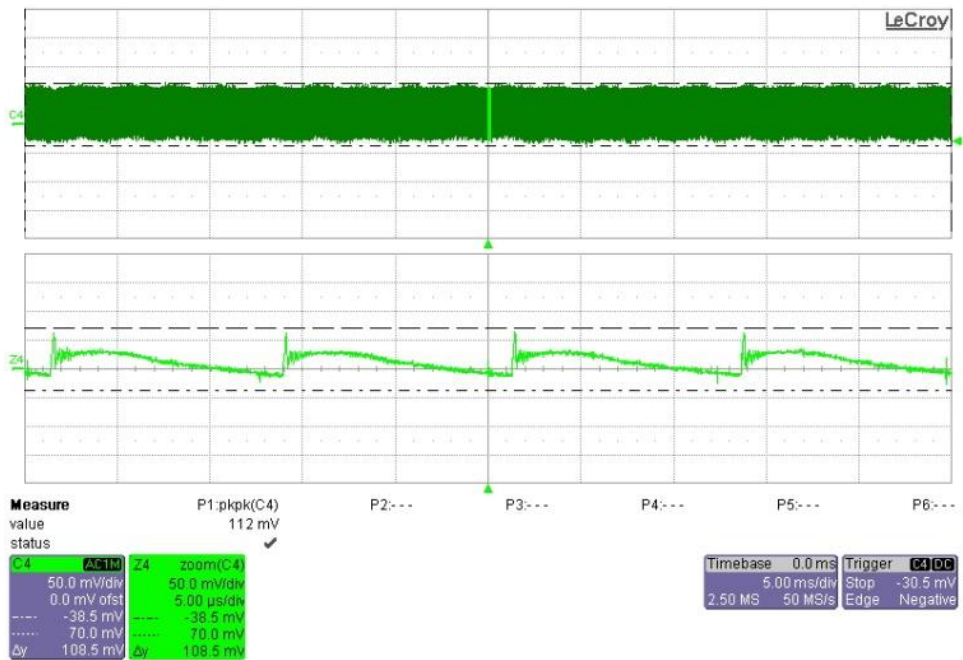


Figure 17. 264 V_{AC}, Full-Load (CH4: V_{OUT})

9.6. Normal Operation

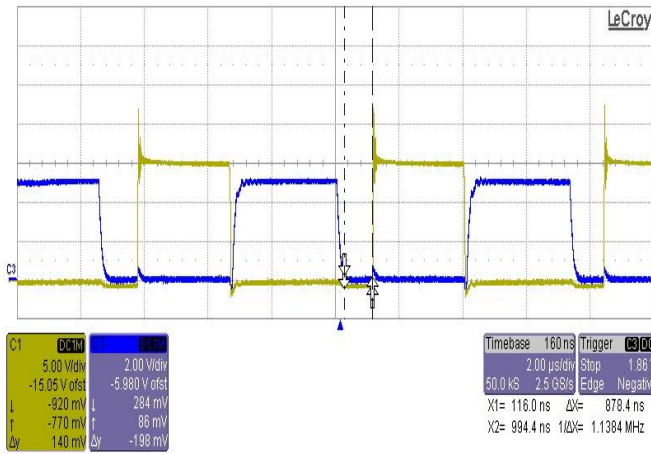


Figure 18. $t_{\text{deadtime}}=878$ ns, 85 V_{AC}, Full-Load (CH1: DET, CH3: SR Gate)

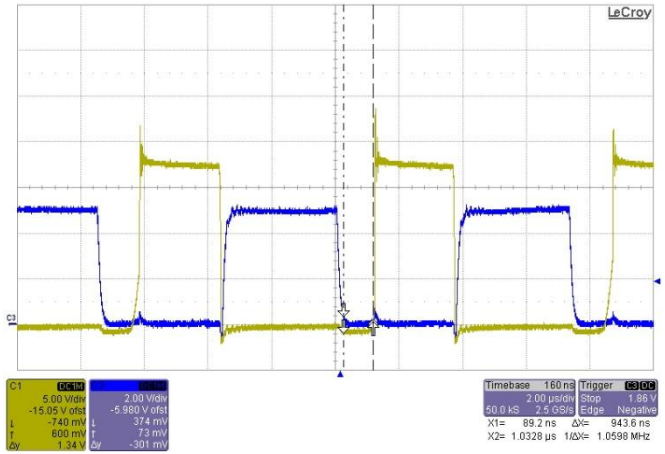


Figure 19. $t_{\text{deadtime}}=943$ ns, 115 V_{AC}, Full-Load (CH1: DET, CH3: SR Gate)

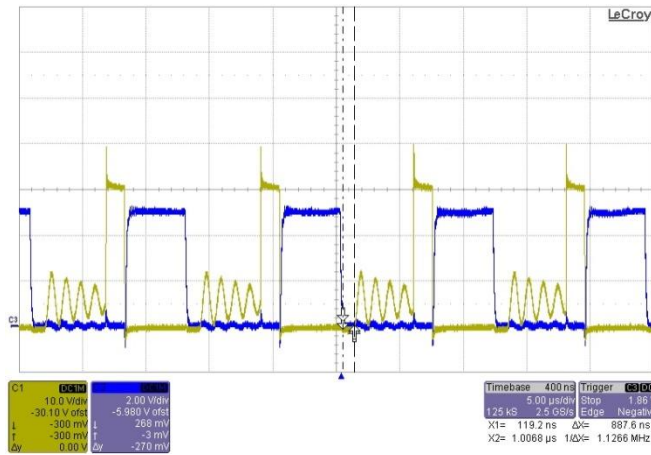


Figure 20. $t_{\text{deadtime}}=887$ ns, 230 V_{AC}, Full-Load (CH1: DET, CH3: SR Gate)

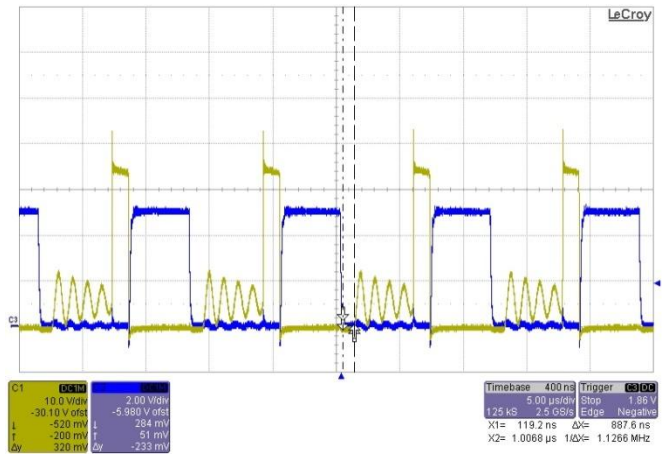


Figure 21. $t_{\text{deadtime}}=887$ ns, 264 V_{AC}, Full-Load (CH1: DET, CH3: SR Gate)

9.7. Turn-On Rising

Table 7. Measurement Output Voltage of 10% to 90%, End of Cable

| t_{rising} | Loading | 85 V _{IN} | 115 V _{IN} | 230 V _{IN} | 264 V _{IN} |
|---------------------|-----------|--------------------|---------------------|---------------------|---------------------|
| | No Load | 10 ms | 13 ms | 12.9 ms | 12 ms |
| | Full Load | 10 ms | 11.1 ms | 10 ms | 12 ms |

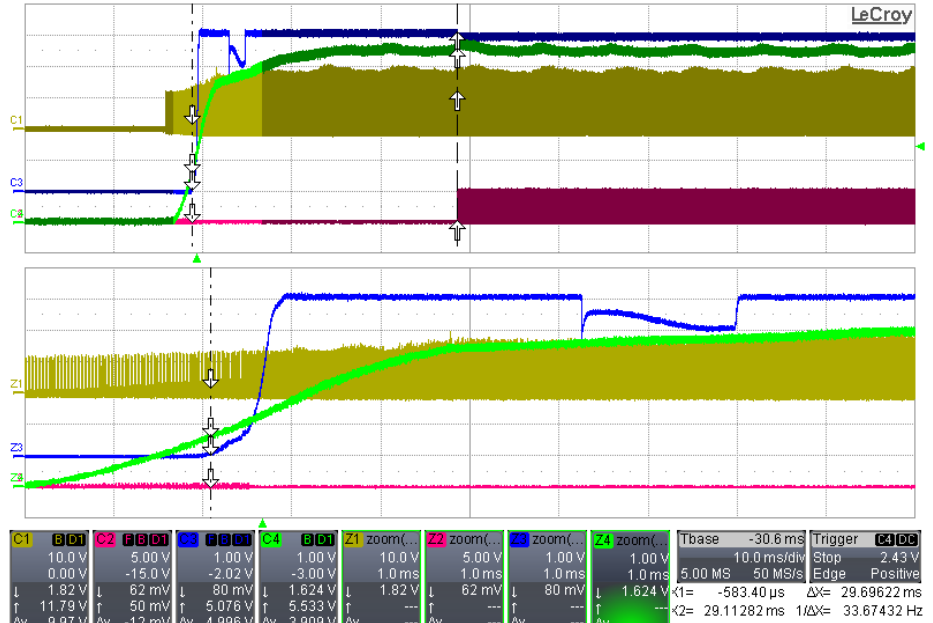


Figure 22. 85 V_{AC}, Full-Load (CH1: DET, CH2: SR V_{DD}, CH3: SR V_{DD}, CH4: V_{OUT})

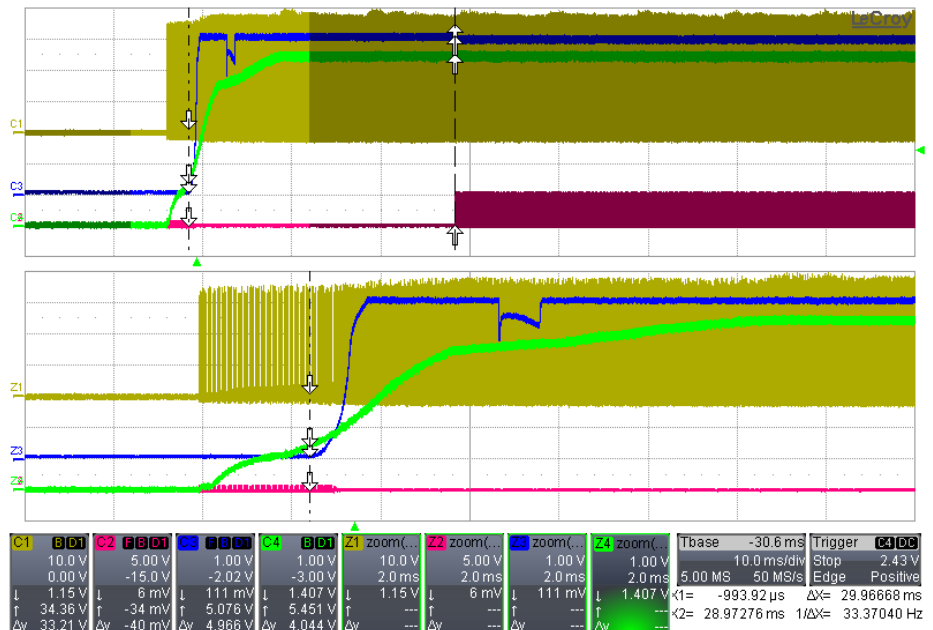


Figure 23. 264 V_{AC}, Full-Load (CH1: DET, CH2: SR V_{DD}, CH3: SR V_{DD}, CH4: V_{OUT})

9.8. Brownout Test

Table 8. Brownout Voltage at Maximum Load (CC Mode), End of Board

| Input Voltage (V) | Input Wattage (W) | Output Voltage (V) |
|-------------------|-------------------|--------------------|
| 90 | 16.11 | 5.59 |
| 80 | 16.08 | 5.51 |
| 70 | 16.18 | 5.51~5.06 |
| 60 | 14.70 | 5.51~3.11 |
| 53 | 0 | 0 |

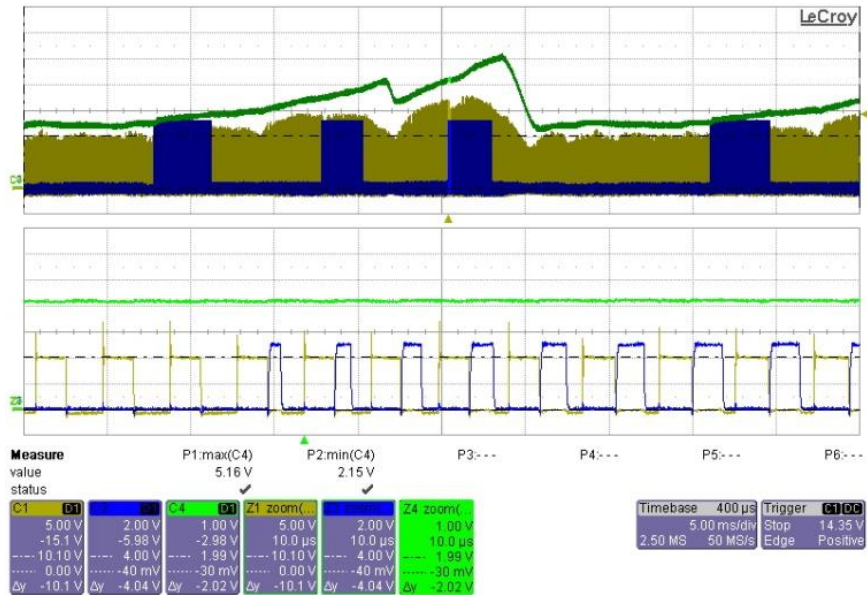


Figure 24. 54 V_{AC}, Full-Load (CH1: DET, CH2: SR V_{DD}, CH4: V_{OUT})

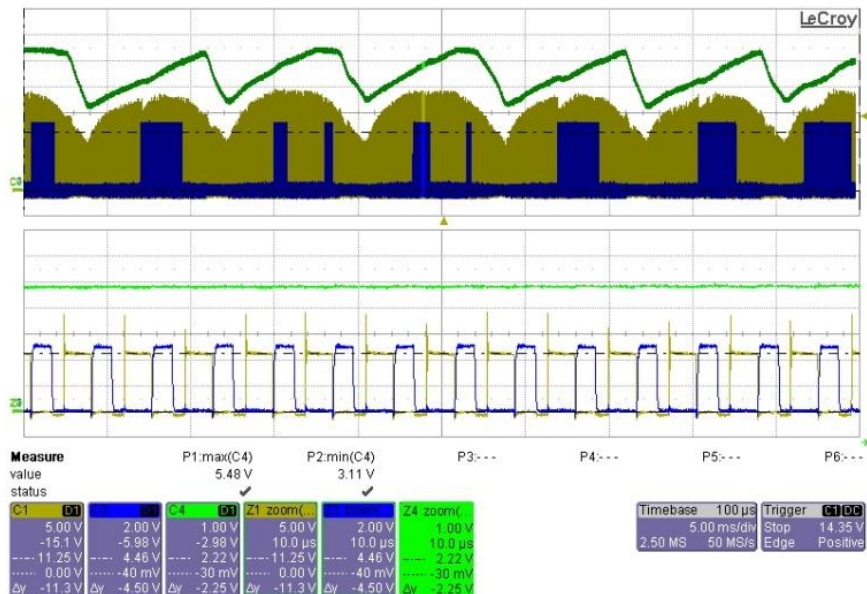


Figure 25. 54 V_{AC}, Full-Load (CH1: DET, CH2: SR V_{DD}, CH4: V_{OUT})

9.9. $V_{DD_1st\&2st}$ Voltage Level

Table 9. V_{DD} with Control IC of Primary and Secondary Sides

| V_{IN} | No Load | | Max. Load | | Near OPP (V) | |
|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | V_{DD_1st} | V_{DD_2st} | V_{DD_1st} | V_{DD_2st} | V_{DD_1st} | V_{DD_2st} |
| 85 V / 60 Hz | 10.36 V | 4.49 V | 17.34 V | 5.04 V | 17.71 V | 5.04 V |
| 264 V / 50 Hz | 10.15 V | 4.50 V | 18.33 V | 5.09 V | 18.8 V | 5.09 V |

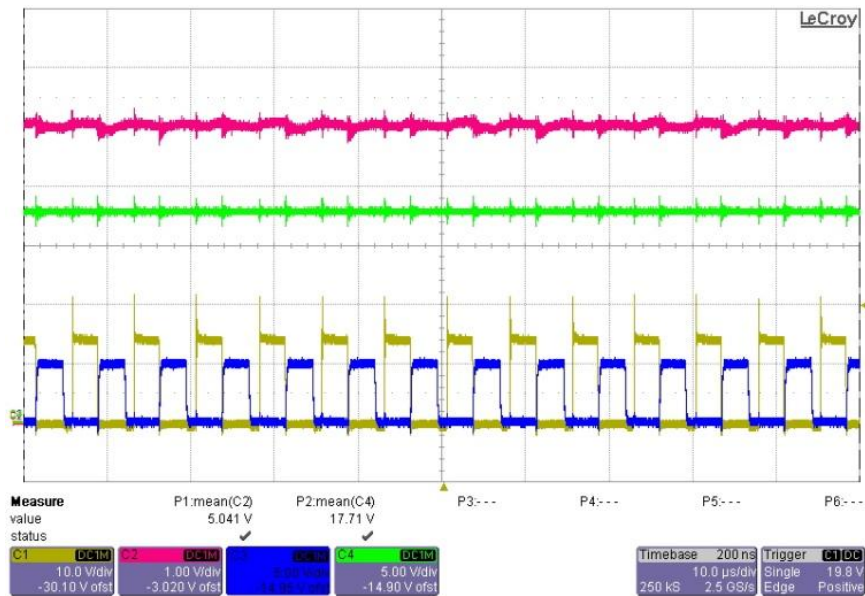


Figure 26. 85 V_{AC}, Near OPP (CH1: DET, CH2: SR V_{DD}, CH3: SR Gate, CH4: V_{DD_1st})

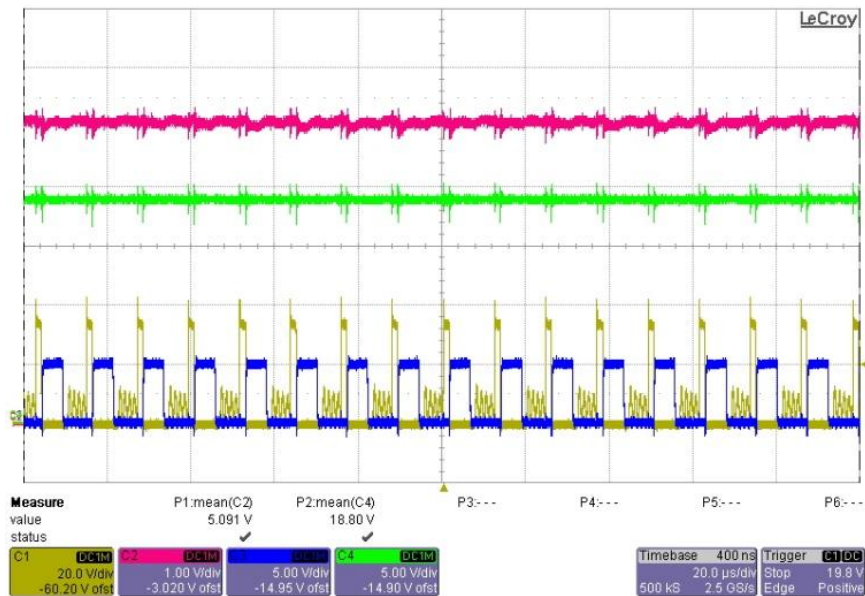


Figure 27. 264 V_{AC}, Near Over-Power Protection (CH1: DET, CH2: SR V_{DD}, CH3: SR Gate, CH4: V_{DD_1st})

9.10. Maximum Power Level

Table 10. Maximum Power Level, End of Board

| Input Voltage | Output Current (A) | Output Voltage (V) | Output Wattage (W) |
|---------------|--------------------|--------------------|--------------------|
| 85 V / 60 Hz | 2.74 | 5.546 | 15.18 |
| 115 V / 60 Hz | 2.71 | 5.722 | 15.53 |
| 230 V / 60 Hz | 2.68 | 5.802 | 15.56 |
| 264 V / 60 Hz | 2.69 | 5.836 | 15.73 |

9.11. Output Short Protection

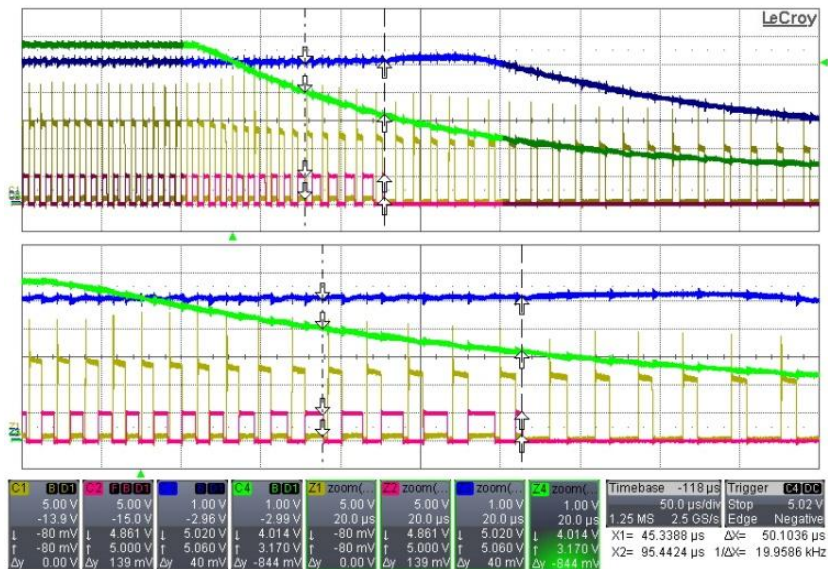


Figure 28. 85 V_{AC}, Short at Full Load (CC Mode)
(CH1: DET, CH2: SR Gate, CH3: SR V_{DD}, CH4: V_O)

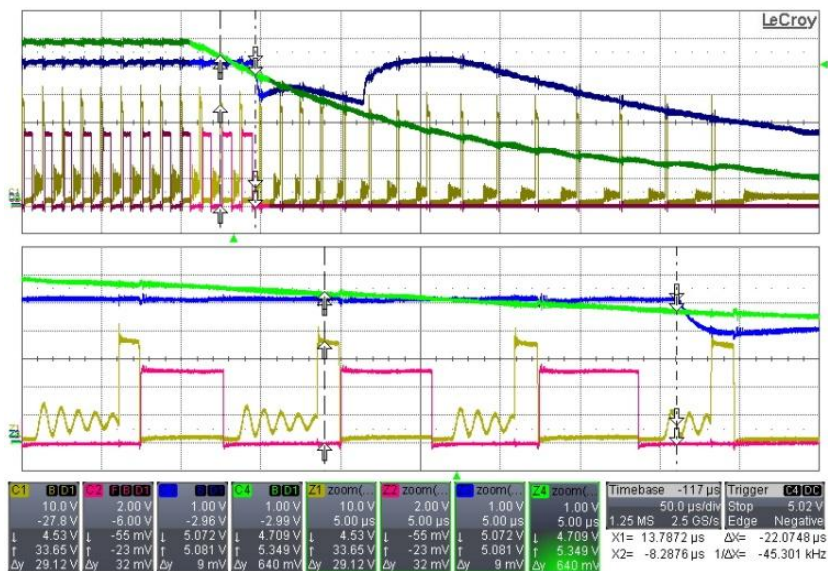


Figure 29. 264 V_{AC}, Short at Full Load (CC Mode)
(CH1: DET, CH2: SR Gate, CH3: SR V_{DD}, CH4: V_O)

9.12. Dynamic Response

Table 11. Dynamic Test

Conditions: 5 ms duty cycle, 2.5 A/ μ s rise/fall time, level in end of cable line

| | 85 V _{IN} | | 264 V _{IN} | |
|----------|--------------------|------------|---------------------|------------|
| | Overshoot | Undershoot | Overshoot | Undershoot |
| 0%~50% | 5.315 V | 4.670 V | 5.360 V | 4.665 V |
| 50%~100% | 5.380 V | 4.935 V | 5.535 V | 5.010 V |
| 0%~100% | 5.375 V | 4.335 V | 5.500 V | 4.315 V |

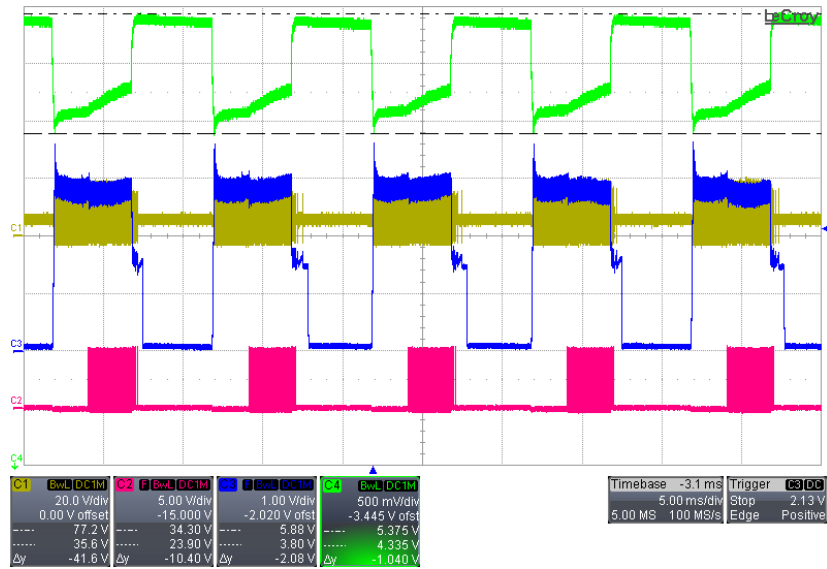


Figure 30. 85 V_{AC}, Loading of 0%~100% (CC Mode)
(CH1: DET, CH2: SR Gate, CH3: V_{FB}, CH4: V_O)

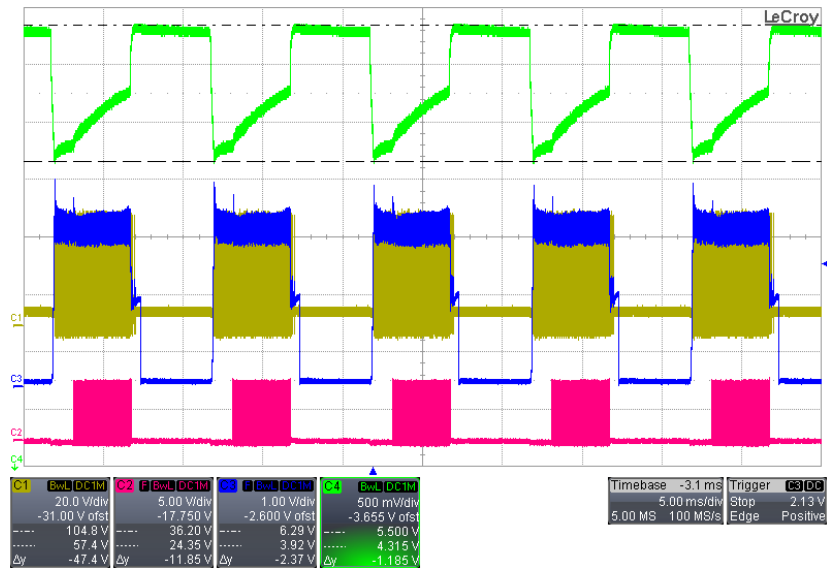


Figure 31. 264 V_{AC}, Loading of 0%~100% (CC Mode)
(CH1: DET, CH2: SR Gate, CH3: V_{FB}, CH4: V_O)

9.13. Voltage Stress on Drain_{1st&2st}

Table 12. Voltage Stress on Primary MOSFET and Secondary MOSFET

| Input Voltage | Condition | Drain _{1st} | Rating | Drain _{2st} | Rating |
|-----------------------------|----------------------|----------------------|--------|----------------------|--------|
| 85 V _{IN} / 60 Hz | Full Load | 277 V | 600 V | 22.2 V | 60 V |
| | Startup at Full Load | 279 V | | 22.2 V | |
| | Short at Full Load | 266 V | | 20.25 V | |
| 264 V _{IN} / 50 Hz | Full Load | 560 V | | 44.2 V | |
| | Startup at Full Load | 557 V | | 43.9 V | |
| | Short at Full Load | 544 V | | 42.3 V | |



Figure 32. 85 V_{AC}, AC Start at Full-Load (CH1: DET, CH3: Drain_{1st})

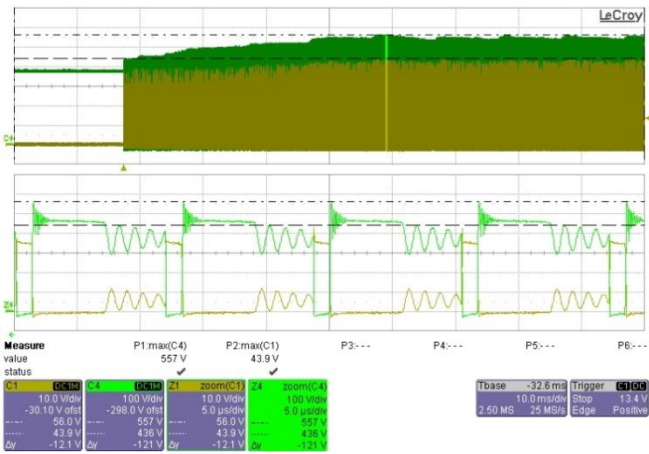


Figure 33. 264 V_{AC}, AC Start at Full-Load (CH1: DET, CH3: Drain_{1st})



Figure 34. 85 V_{AC}, Output Short at Full-Load (CH1: DET, CH3: Drain_{1st})

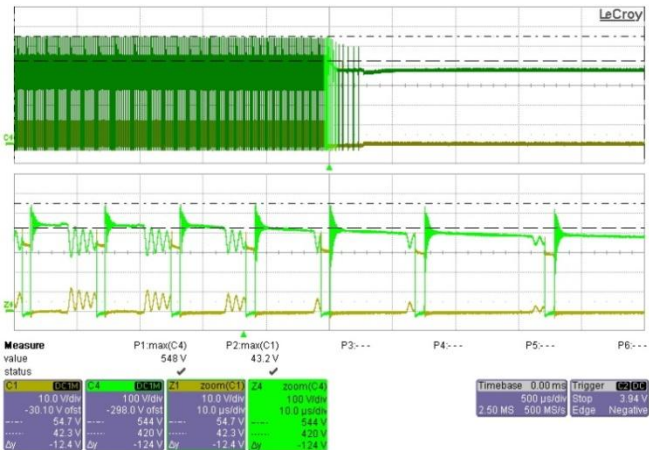
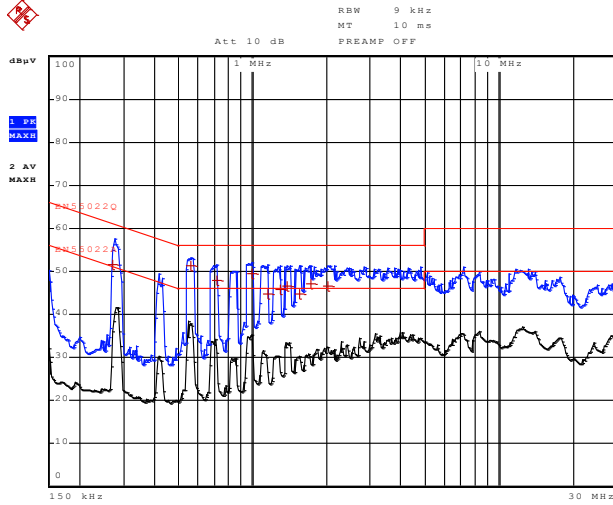


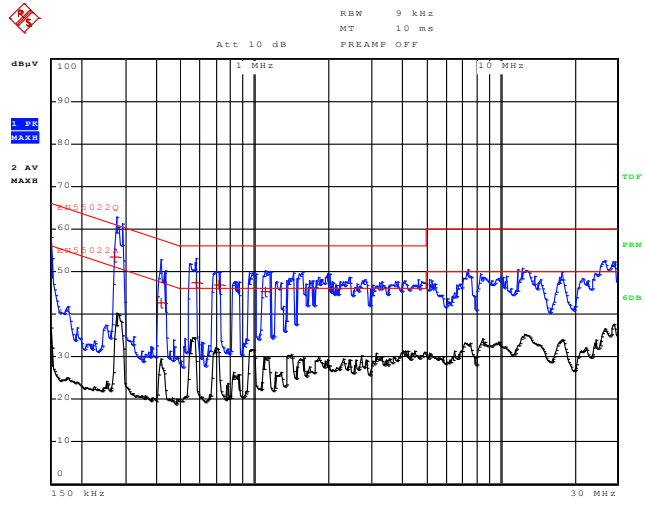
Figure 35. 264 V_{AC}, Output Short at Full-Load (CH1: DET, CH3: Drain_{1st})

9.14. Conducted EMI Measurement



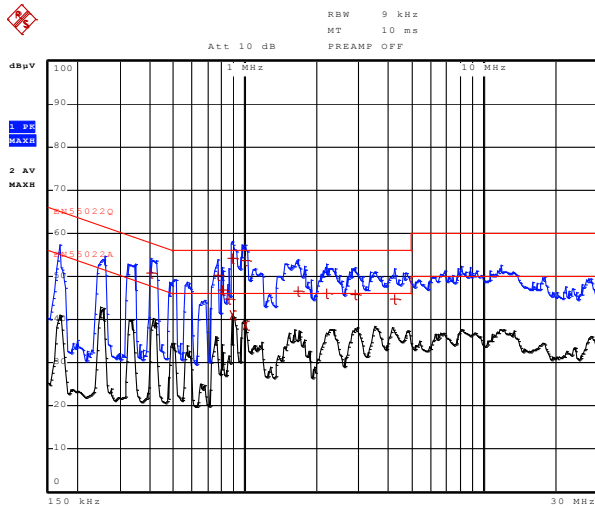
Comment: 2-230N
Date: 10.SEP.2013 18:22:16

Figure 36. Line at 115 V_{AC}



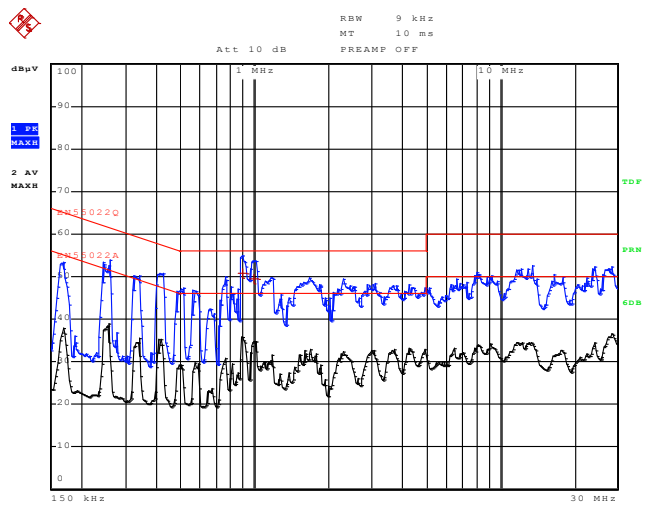
Comment: 2-230N
Date: 10.SEP.2013 18:18:21

Figure 37. Nature at 115 V_{AC}



Comment: 2-230N
Date: 10.SEP.2013 18:28:09

Figure 38. Line at 115 V_{AC}



Comment: 2-230N
Date: 10.SEP.2013 18:32:36

Figure 39. Nature at 115 V_{AC}



10. Revision History

| Rev. | Date | Description |
|------|---------|-----------------|
| 1.0 | 12/2014 | Initial release |
| | | |
| | | |
| | | |

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