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**User Guide for  
FEBFAN7631\_L17U120A**

**120 W LED Driver at Universal Line**

**Featured Fairchild Products:**

**FSL117MRIN**

**FL7930C**

**FAN7631**

**FAN73402**

*Direct questions or comments  
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## Table of Contents

|       |  |    |
|-------|--|----|
| 1.    | Introduction.....                                    | 3  |
| 1.1.  | General Description of FSL117MIRN.....               | 3  |
| 1.2.  | Features.....  | 4  |
| 1.3.  | Internal Block Diagram.....                          | 4  |
| 1.4.  | General Description of FL7930C.....                  | 5  |
| 1.5.  | Features.....  | 5  |
| 1.6.  | Internal Block Diagram.....                          | 6  |
| 1.7.  | General Description of FAN7631.....                  | 6  |
| 1.8.  | Features.....  | 7  |
| 1.9.  | Internal Block Diagram.....                          | 7  |
| 1.10. | General Description of FAN73402.....                 | 8  |
| 1.11. | Features.....  | 8  |
| 1.12. | Internal Block Diagram.....                          | 9  |
| 2.    | Specifications for Evaluation Board.....             | 10 |
| 3.    | Photographs.....                                     | 11 |
| 4.    | Printed Circuit Board (PCB).....                     | 12 |
| 5.    | Schematic.....                                       | 13 |
| 6.    | Bill of Materials.....                               | 18 |
| 7.    | Transformer Design.....                              | 22 |
| 7.1.  | Flyback Transformer (TS801).....                     | 22 |
| 7.2.  | PFC Inductor (LP801).....                            | 23 |
| 7.3.  | LLC Transformer (TM801).....                         | 24 |
| 8.    | Performance of Evaluation Board.....                 | 25 |
| 8.1.  | System Efficiency.....                               | 25 |
| 8.2.  | Power Factor and Total Harmonic Discharge (THD)..... | 27 |
| 8.3.  | Constant-Current and voltage Regulation.....         | 28 |
| 8.4.  | Overall Startup Performance.....                     | 29 |
| 8.5.  | Startup Performance in Flyback Stage.....            | 30 |
| 8.6.  | Startup Performance in PFC stage.....                | 31 |
| 8.7.  | Startup Performance in LLC Stage.....                | 32 |
| 8.8.  | Key Waveforms for Input and Output.....              | 33 |
| 8.9.  | Key Waveforms for Flyback Stage.....                 | 34 |
| 8.10. | Key Waveforms for PFC Stage.....                     | 35 |
| 8.11. | Key Waveforms for LLC Stage.....                     | 37 |
| 8.12. | Key Waveforms for Single-Channel Boost Stage.....    | 39 |
| 8.13. | Dimming Performance.....                             | 40 |
| 8.14. | LED Short/Open Protection at Multi CH Output.....    | 42 |
| 8.15. | Operating Temperature.....                           | 43 |
| 9.    | Revision History.....                                | 44 |

This user guide supports the evaluation kit for the FSL117MRIN, FL7930C, FAN7631, and FAN73402; orderable as FEB-L017U120B. It should be used in conjunction with the product datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at [www.fairchildsemi.com](http://www.fairchildsemi.com).

## 1. Introduction

This document describes a proposed solution for a 120 W LED driver consisting of an AC-DC converter for flyback bias regulation, a boost converter for Power-Factor-Correction (PFC), an LLC resonant converter for a single LED channel with constant current and voltage or individual boost converters for two LED channels with constant current and dimming control. The input voltage range is  $85 V_{RMS} - 300 V_{RMS}$  and there are DC outputs with a constant current of 2.4 A at  $50 V_{MAX}$  for a single LED channel or with constant current and dimming of 1.2 V at 100 V for two LED channels.

The power supply mainly utilizes:

- FSL117MRIN – Green Mode Fairchild Power Switch (FPST™)
- FL7930B – CRM PFC Controller
- FAN7631 – Half-Bridge LLC Controller
- FAN73402 – Single-Channel Boost Controller (for each controller)
- FCPF190N60E and FCPF600N60Z – Fairchild SuperFET® Technology
- FDPF14N30 – Fairchild UniFET® Technology N-Channel MOSFET
- FFPF08H60S – Fairchild Hyperfast Rectifier
- MBR20200CT – Fairchild Schottky Rectifier
- RURD620CCS9A – Fairchild Ultra-Fast Recovery Rectifier (for discrete)

This document contains important information (e.g. schematic, bill of materials, printed circuit board layout, transformer design documentation), and the typical operating characteristics supporting this evaluation board.

### 1.1. General Description of FSL117MRIN

The FSL117MRIN is an integrated Pulse Width Modulation (PWM) controller and 700 V SenseFET specifically designed for offline Switched-Mode Power Supplies (SMPS) with minimal external components. The PWM controller includes an integrated fixed-frequency oscillator, Line Over-Voltage Protection (LOVP), Under-Voltage Lockout (UVLO), Leading-Edge Blanking (LEB), optimized gate driver, internal soft-start, temperature-compensated precise current sources for loop compensation, and self-protection circuitry. Compared with a discrete MOSFET and PWM controller solution, the FSL117MRIN can reduce total cost, component count, size, and weight; while simultaneously increasing efficiency, productivity, and system reliability. This device provides a basic platform for cost-effective design of a flyback converter.

### 1.1.1. Features

- Advanced Soft Burst Mode for Low Standby Power and Low Audible Noise
- Random Frequency Fluctuation (RFF) for Low Electromagnetic Interference (EMI)
- Pulse-by-Pulse Current Limit
- Overload Protection (OLP), Over-Voltage Protection (OVP), Abnormal Over-Current Protection (AOCP), Internal Thermal Shutdown (TSD) with Hysteresis, Output-Short Protection (OSP), Line Over-Voltage Protection (LOVP), and Under-Voltage Lockout (UVLO) with Hysteresis
- Low Operating Current (0.4 mA) in Burst Mode
- Internal Startup Circuit
- Internal Avalanche-Rugged 700 V SenseFET
- Built-in Soft-Start: 15 ms
- Auto-Restart Mode

### 1.1.2. Internal Block Diagram

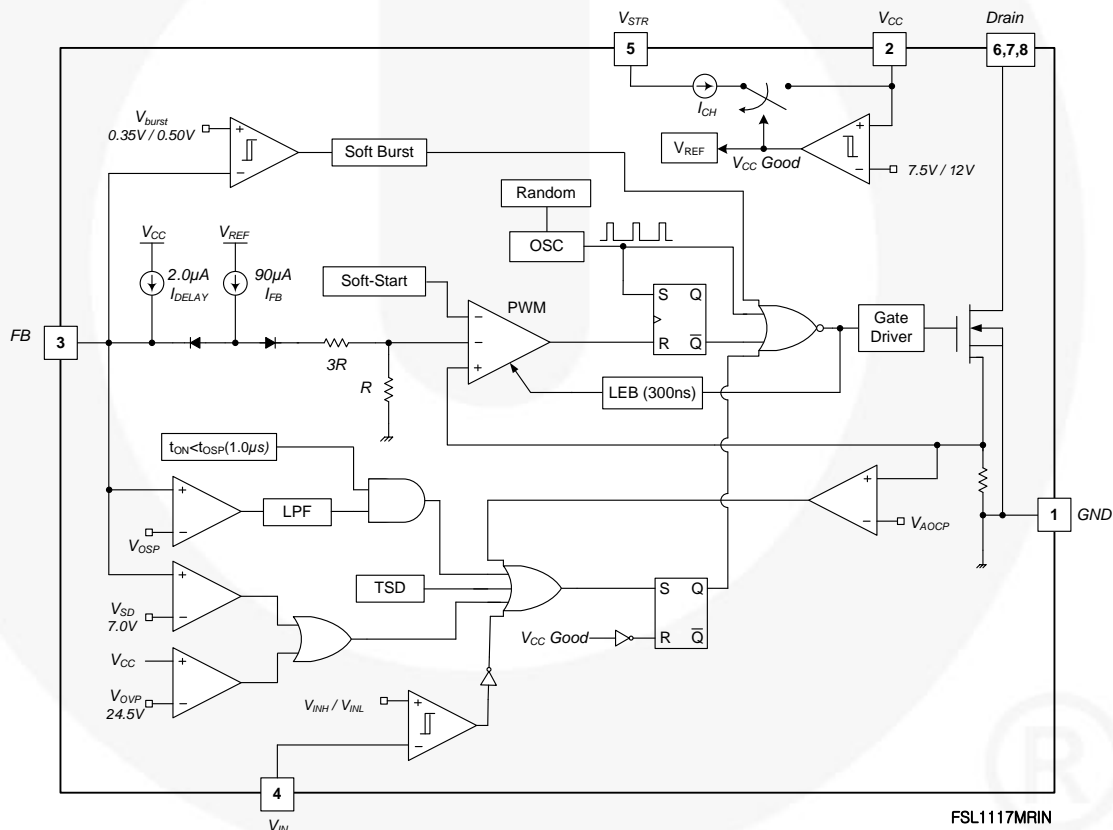


Figure 1. Block Diagram of FSL117MRIN

## 1.2. General Description of FL7930C

The FL7930C is an active Power Factor Correction (PFC) controller for low- to high-power lumens applications that operate in Critical Conduction Mode (CRM). It uses a voltage-mode PWM that compares an internal ramp signal with the error amplifier output to generate a MOSFET turn-off signal. Because the voltage-mode CRM PFC controller does not need rectified AC line voltage information, it saves the power loss of an input voltage-sensing network. FL7930B provides over-voltage, open-feedback, over-current, input-voltage-absent detection, and under-voltage lockout protections. The FL7930B can be disabled if the INV pin voltage is lower than 0.45 V and the operating current decreases to a very low level. Using a new variable on-time control method, Total Harmonic Discharge (THD) is lower than conventional CRM boost PFC ICs. The FL7930C provides a PFC Ready pin that can be used to shutdown the boost power stage when PFC output voltage reaches the proper level (with hysteresis).

### 1.2.1. Features

- Additional PFC-Ready Function
- Input-Voltage-Absent-Detection Circuit
- Maximum Switching Frequency Limitation.
- Internal Soft-Start with Overshoot Prevention
- Internal Total harmonic Distortion (THD) Optimizer
- Precise Adjustable Output Over-Voltage Protection (OVP)
- Open-Feedback Protection and Disable Function
- Zero Current Detector (ZDC)
- 150  $\mu$ s Internal Startup Timer
- MOSFET Over-Current Protection (OCP)
- Under-Voltage Lockout with 3.5 V Hysteresis (UVLO)
- Low Startup (40  $\mu$ A) and Operating Current (1.5 mA)
- Totem-Pole Output with High State Clamp
- +500 / -800 mA Peak Gate Drive Current
- SOP-8 Package

### 1.2.2. Internal Block Diagram

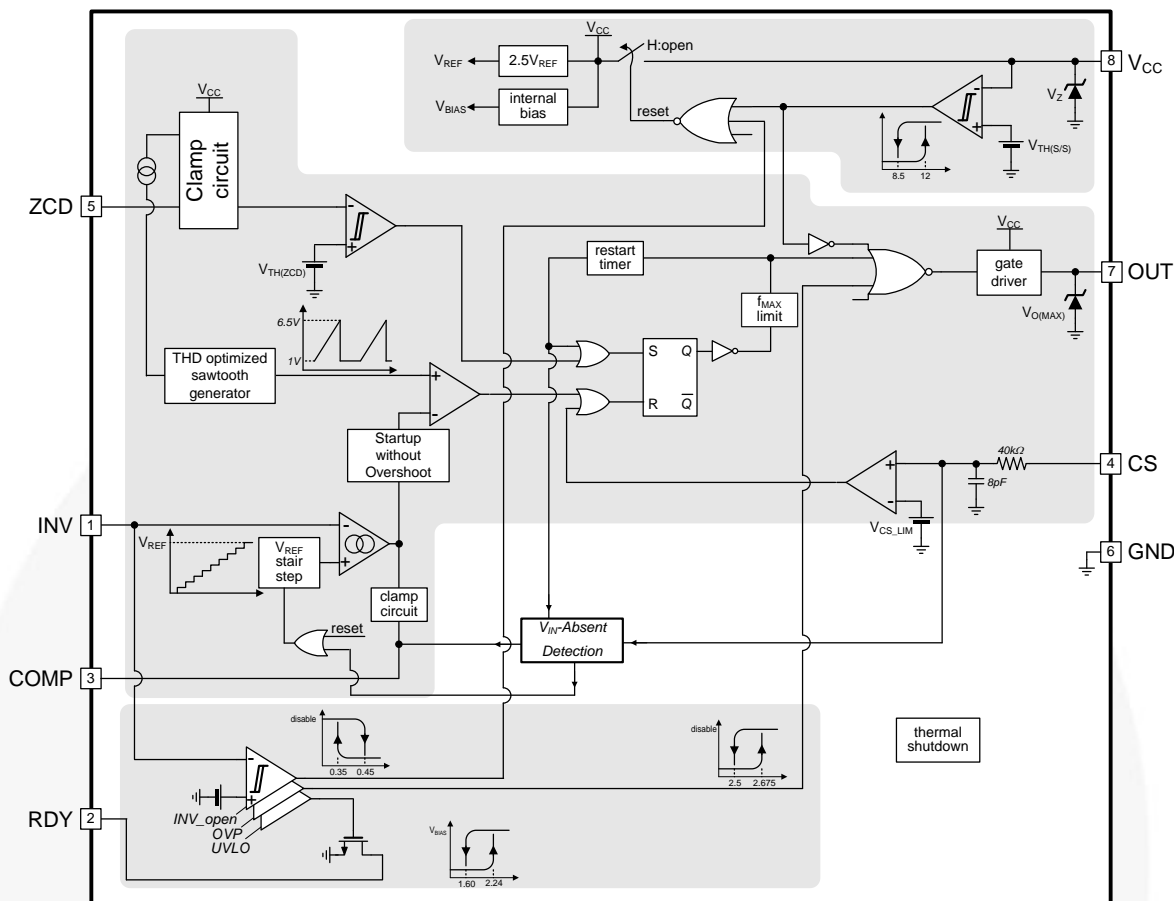


Figure 2. Block Diagram of FL7930C

### 1.3. General Description of FAN7631

The FAN7631 is a pulse-frequency modulation controller for high-efficiency half-bridge resonant converters that includes a high-side gate drive circuit, an accurate current-controlled oscillator, and various protection functions. The FAN7631 features include variable dead time, high operating frequency up to 600 kHz, protections such as LUVLO, and a selectable latch or A/R protection using the LS pin for user convenience. The Zero-Voltage-Switching (ZVS) technique reduces the switching losses and improves the efficiency significantly. ZVS also reduces the switching noise noticeably, which allows a small Electromagnetic Interference (EMI) filter. Offering everything necessary to build a reliable and robust resonant converter, the FAN7631 simplifies designs and improves productivity and performance. The FAN7631 can be applied to resonant converter topologies such as series resonant, parallel resonant, and LLC resonant converters.



### 1.3.1. Features

- Variable Frequency Control with 50% Duty Cycle for Half-bridge Resonant Converter Topologies
- High Efficiency through Zero-Voltage-Switching (ZVS)
- Up to 600 kHz Operating Frequency
- High Gate-Driving Current +500 mA/-1000 mA
- Precise Adjustable Output Over-Voltage Protection (OVP)
- Programmable Dead Time using a Resistor
- Pulse Skipping and Burst Operation for Frequency Limit (programmable) at Light-Load Condition
- Simple Remote on/off Control with Selectable Latch or A/R using FI or LS pin
- Protection Function; Over-Voltage Protection (OVP), Overload Protection (OLP), Over-Current Protection (OCP), Abnormal Over-Current Protection (AOCP), Internal Thermal Shutdown (TSD) and High Precise Line Under-Voltage Lockout (LUVLO)
- Level-Change OCP Function during Startup.
- SOP-16 Package

### 1.3.2. Internal Block Diagram

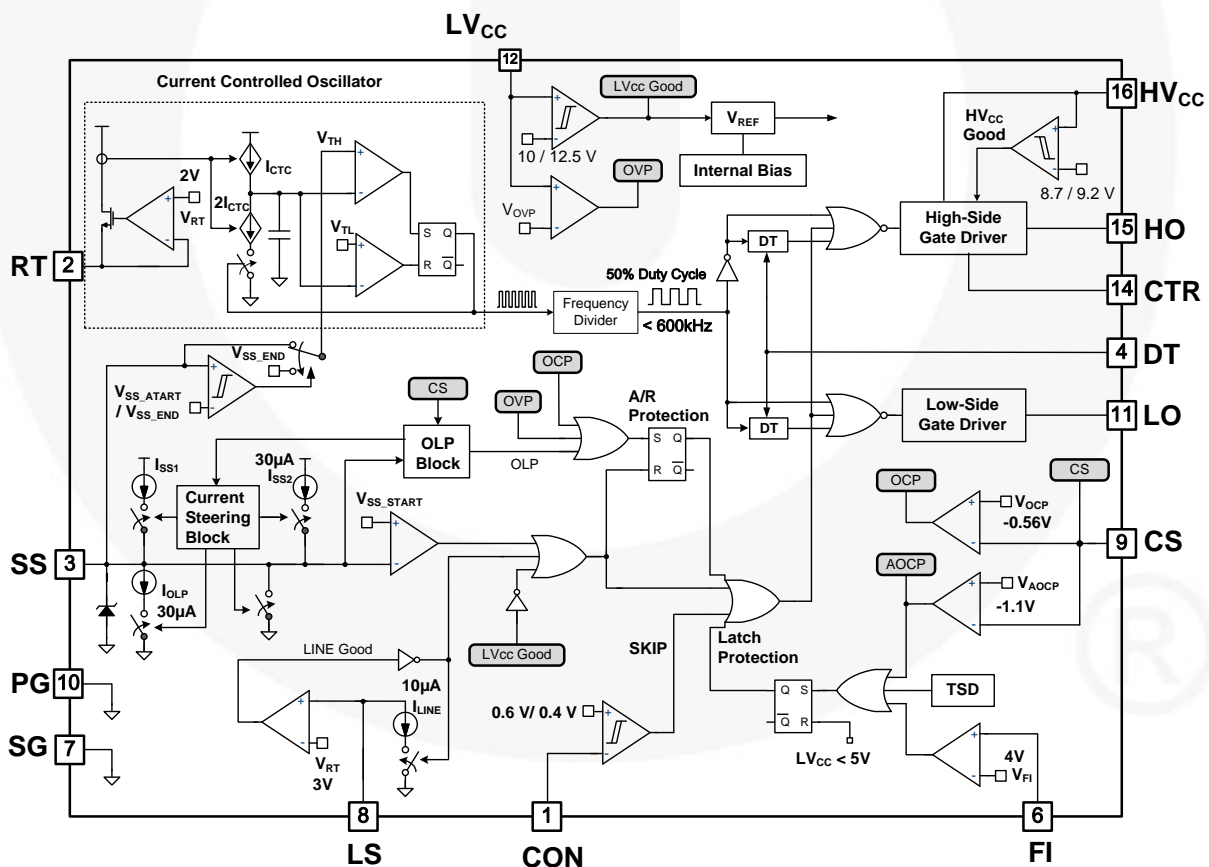


Figure 3. Block Diagram of FAN7631

## 1.4. General Description of FAN73402

The FAN73402 is a single-channel boost controller that integrates an N-channel power MOSFET for PWM dimming using Fairchild's proprietary planar Double-diffused MOSFET (DMOS) technology. The IC operates as a constant-current source for driving high-current LEDs. It uses Current Mode control with programmable slope compensation to prevent sub-harmonic oscillation. The IC provides protections including: open-LED protection, over-voltage protection, and direct-short protection for high system reliability. The IC internally generates a FAULT signal with delay if an abnormal LED string condition occurs. PWM dimming and analog dimming functions can be implemented independently. Internal soft-start prevents inrush current flowing into output capacitor at startup.

### 1.4.1. Features

- Single-Channel Boost LED Switch
- Internal Power MOSFET for PWM Dimming:  
 $R_{DS(ON)}=1.0\ \Omega$  at  $V_{GS}=10\ V$ ,  $BV_{DSS}=200\ V$
- Current-Mode PWM Control
- Internal Programmable Slope Compensation
- Wide Supply Voltage Range: 10 V to 35 V
- LED Current Regulation:  $\pm 1\%$
- Programmable Switching Frequency
- Analog and PWM Dimming
- Wide Dimming Ratio: On Time=10  $\mu s$  to DC
- Cycle-by-Cycle Current Limiting
- Thermal Shutdown: 150°C
- Open-LED Protection (OLP)
- Over-Voltage Protection (OVP)
- Over-Current Protection (OCP)
- Error Flag Generation (for External Load Switch)
- Internal Soft-Start
- 16-Lead SOIC Package

### 1.4.2. Internal Block Diagram

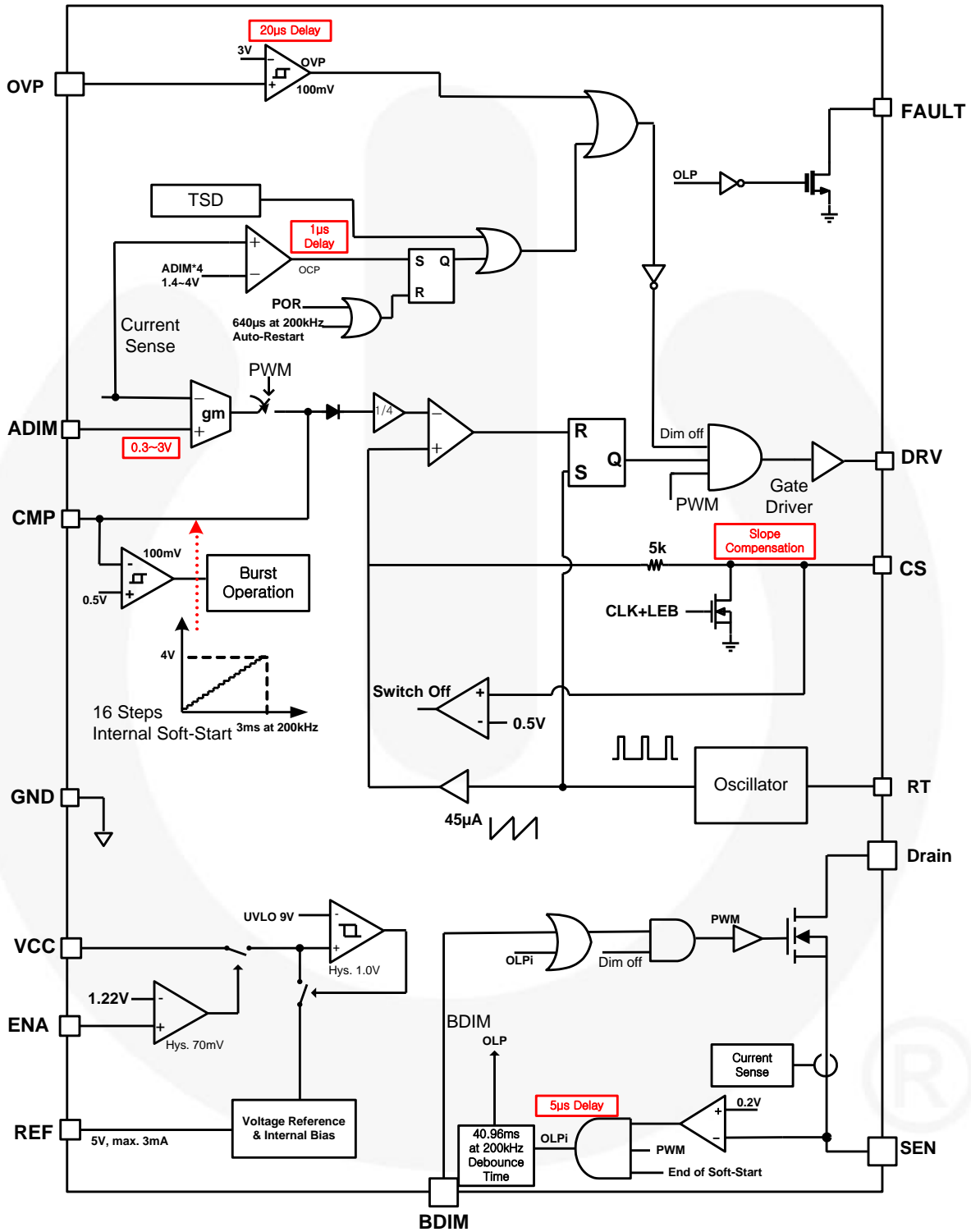


Figure 4. Block Diagram of FAN73402

## 2. Specifications for Evaluation Board

Table 1. Specifications for LED Lighting Lamp

| Description                    |                   | Symbol               | Value               | Comments  |
|--------------------------------|-------------------|----------------------|---------------------|---|
| Input                          | Voltage           | $V_{IN,MIN}$         | 85 V <sub>AC</sub>  | Minimum Input Voltage                                   |
|                                |                   | $V_{IN,MAX}$         | 300 V <sub>AC</sub> | Maximum Input Voltage                                   |
|                                |                   | $V_{IN,NOMINAL}$     | 120 V/230 V         | Nominal Input Voltage                                   |
|                                | Frequency         | $f_{IN}$             | 60 Hz/50 Hz         | Line Frequency  |
| Output                         | Voltage           | $V_{OUT\_SINGLE}$    | 50 V                | Output Voltage for Single Channel LED                   |
|                                |                   | $V_{OUT\_MULTI}$     | 100 V               | Output Voltage for Multi Channel LED                    |
|                                | Current           | $I_{OUT\_SINGLE}$    | 2.4 A               | Output Current for Single Channel LED                   |
|                                |                   | $I_{OUT\_MULTI}$     | 1.2 A               | Output Current for Multi Channel LED                    |
| Efficiency<br>[Single Channel] |                   | $Eff_{85VAC}$        | 87.77%              | Efficiency at 85 V <sub>AC</sub> Line Input Voltage     |
|                                |                   | $Eff_{120VAC}$       | 90.06%              | Efficiency at 120 V <sub>AC</sub> Line Input Voltage    |
|                                |                   | $Eff_{140VAC}$       | 90.86%              | Efficiency at 140 V <sub>AC</sub> Line Input Voltage    |
|                                |                   | $Eff_{180VAC}$       | 91.55%              | Efficiency at 180 V <sub>AC</sub> Line Input Voltage    |
|                                |                   | $Eff_{230VAC}$       | 91.99%              | Efficiency at 230 V <sub>AC</sub> Line Input Voltage    |
|                                |                   | $Eff_{300VAC}$       | 92.33%              | Efficiency at 300 V <sub>AC</sub> Line Input Voltage    |
| Standby Power                  |                   | $P_{85VAC}$          | 0.283 W             | Standby Power at 85 V <sub>AC</sub> Line Input Voltage  |
|                                |                   | $P_{120VAC}$         | 0.306 W             | Standby Power at 120 V <sub>AC</sub> Line Input Voltage |
|                                |                   | $P_{140VAC}$         | 0.315 W             | Standby Power at 140 V <sub>AC</sub> Line Input Voltage |
|                                |                   | $P_{180VAC}$         | 0.319 W             | Standby Power at 180 V <sub>AC</sub> Line Input Voltage |
|                                |                   | $P_{230VAC}$         | 0.341 W             | Standby Power at 230 V <sub>AC</sub> Line Input Voltage |
|                                |                   | $P_{300VAC}$         | 0.397 W             | Standby Power at 300 V <sub>AC</sub> Line Input Voltage |
| PF/THD                         |                   | $PF/THD_{85VAC}$     | 0.998/4.58%         | PF/THD at 85 V <sub>AC</sub> Line Input Voltage         |
|                                |                   | $PF/THD_{120VAC}$    | 0.997/4.65%         | PF/THD at 120 V <sub>AC</sub> Line Input Voltage        |
|                                |                   | $PF/THD_{140VAC}$    | 0.995/4.74%         | PF/THD at 140 V <sub>AC</sub> Line Input Voltage        |
|                                |                   | $PF/THD_{180VAC}$    | 0.992/5.32%         | PF/THD at 180 V <sub>AC</sub> Line Input Voltage        |
|                                |                   | $PF/THD_{230VAC}$    | 0.980/7.89%         | PF/THD at 230 V <sub>AC</sub> Line Input Voltage        |
|                                |                   | $PF/THD_{300VAC}$    | 0.945/15.13%        | PF/THD at 300 V <sub>AC</sub> Line Input Voltage        |
| Temperature                    | <b>FSL117MRIN</b> | $T_{FSL117MRIN}$     | 53.9°C              | FSL117MRIN Temperature at 25°C                          |
|                                | <b>FAN73402</b>   | $T_{FAN73402}$       | 82.1°C              | FAN73402 Temperature at 25°C                            |
|                                | <b>MOSFET</b>     | $T_{PFC}$            | 63.0°C              | PFC MOSFET Temperature at 25°C                          |
|                                |                   | $T_{LLC}$            | 59.2°C              | LLC MOSFET Temperature at 25°C                          |
|                                |                   | $T_{Boost\_Channel}$ | 61.8°C              | Boost Channel MOSFET Temperature at 25°C                |
|                                |                   | $T_{LLC}$            | 67.5°C              | LLC Rectifier Temperature at 25°C                       |
|                                |                   | $T_{Boost\_Channel}$ | 69.5°C              | Boost Channel Rectifier Temperature at 25°C             |
|                                |                   | $T_{LLC}$            | 72.6°C              | LLC Transformer Temperature at 25°C                     |

All data of the evaluation board measured with the board enclosed in a case and external temperature around 25°C.

### 3. Photographs

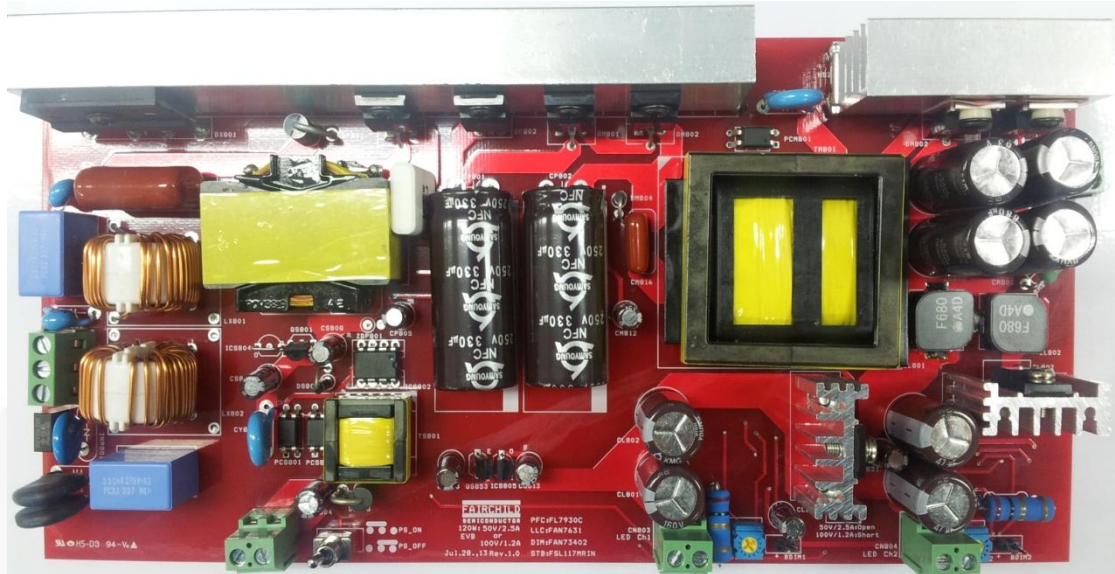


Figure 5. Top View [Dimensions: 232mm (L) x 114 mm (W) x 27 mm (H)]

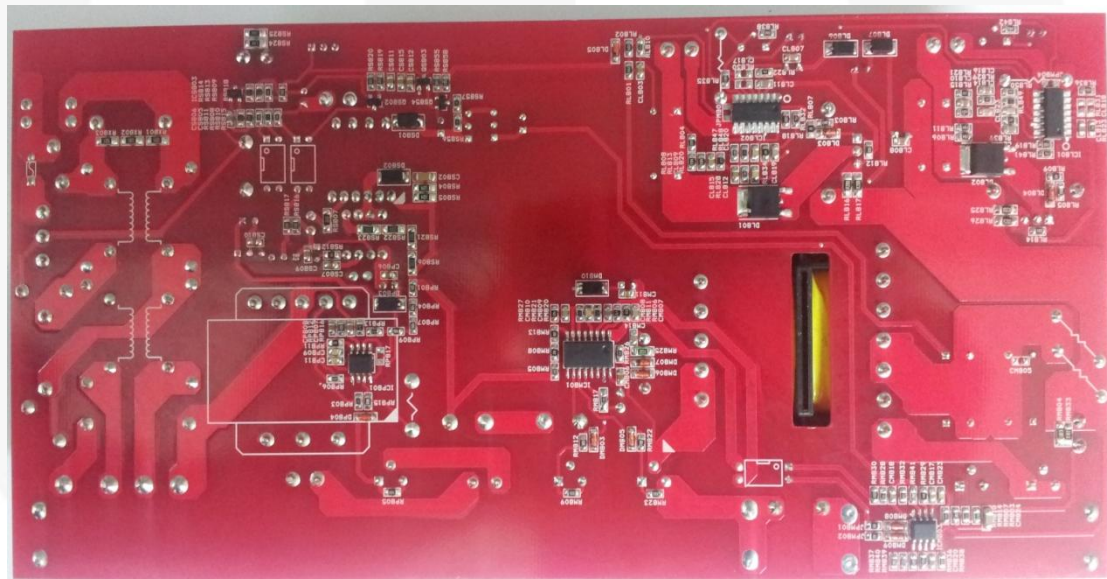


Figure 6. Bottom View [Dimensions: 232mm (L) x 114 mm (W) x 27 mm (H)]



## 5. Schematic

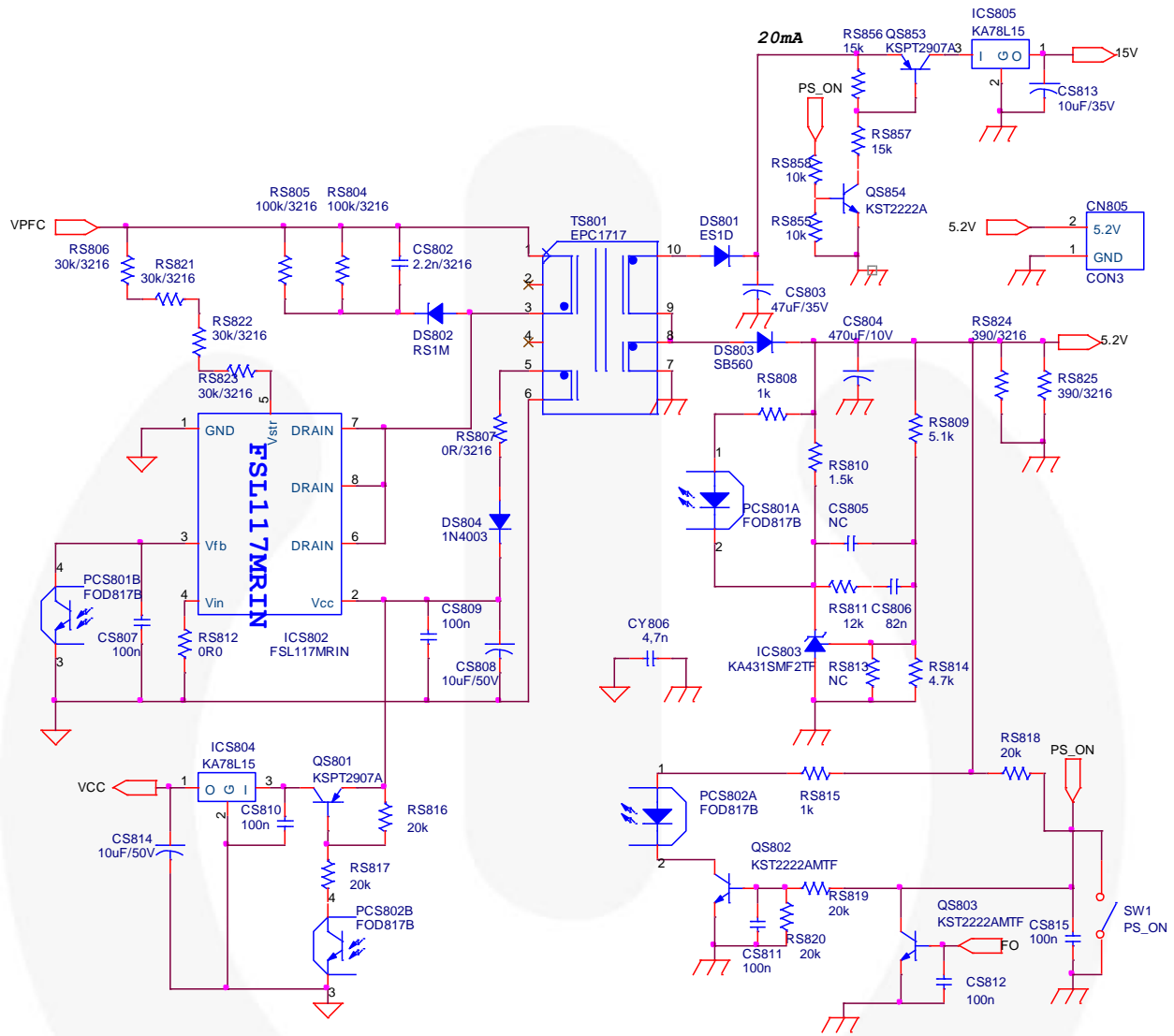


Figure 9. Schematic for Flyback Bias Regulator Part

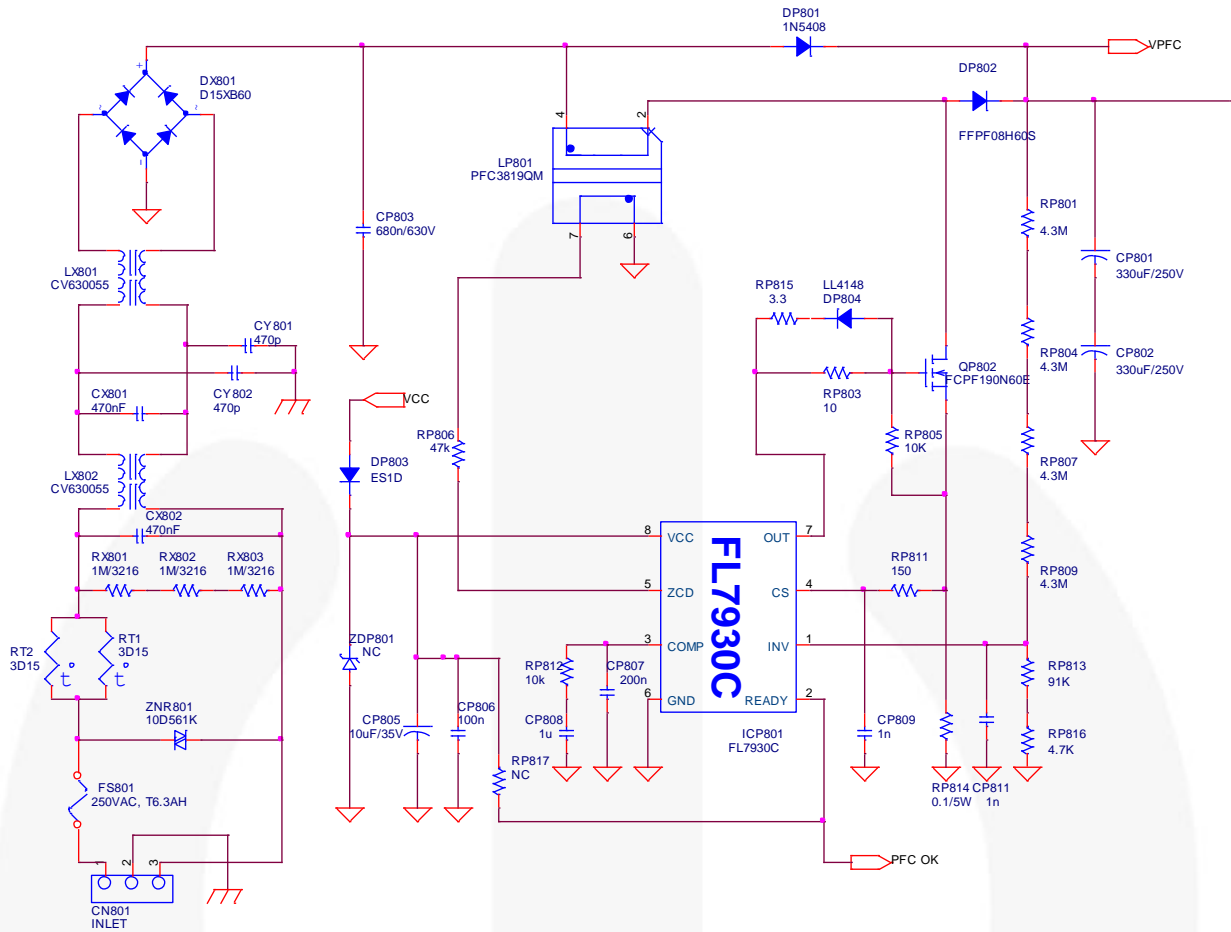


Figure 10. Schematic for PFC Part





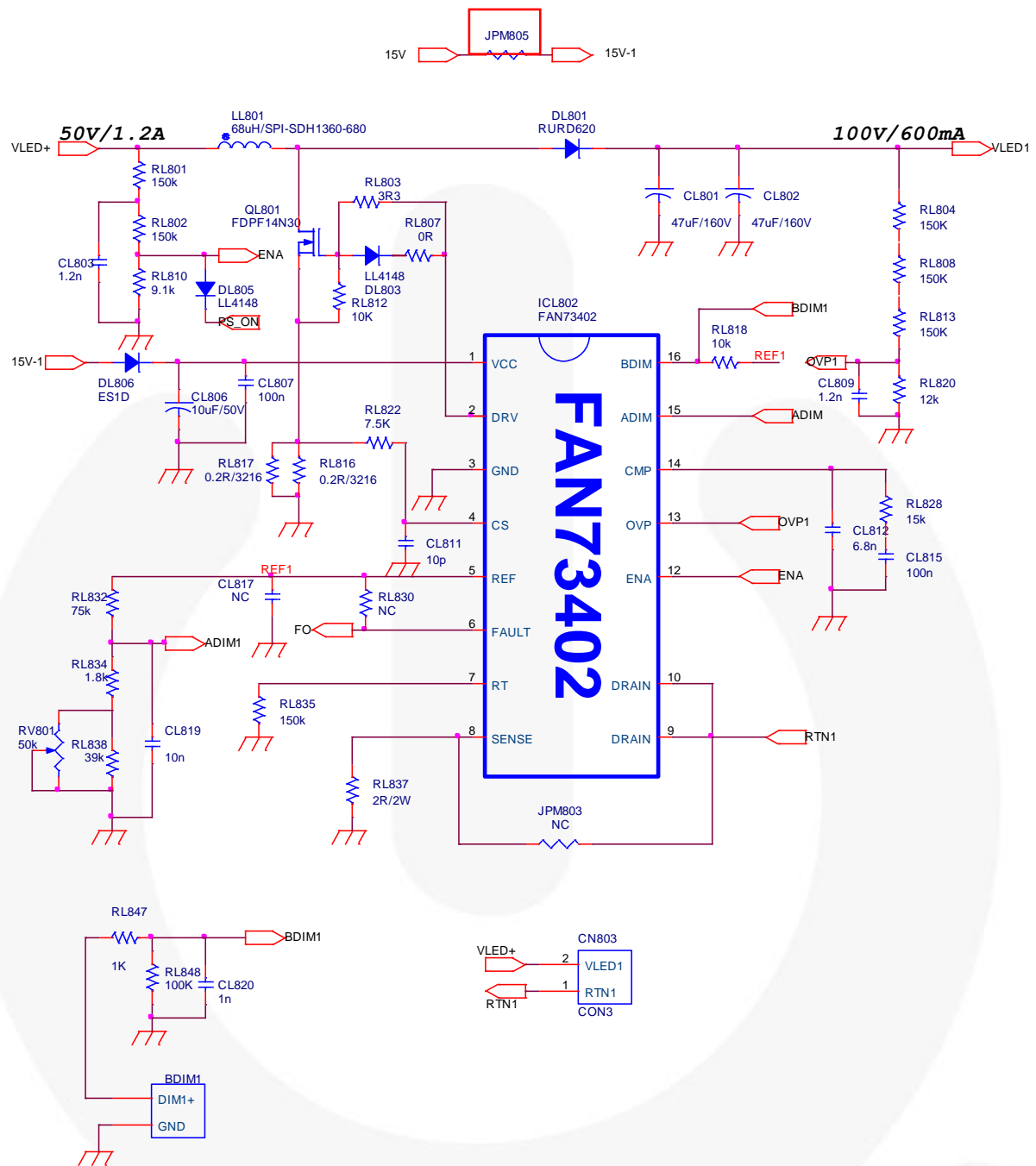


Figure 12. Schematic for Boost Channel 1.

※ JPM805 should be opened in case of 50 V/2.4 A output and shorted in case of 100 V/1.2 A output.

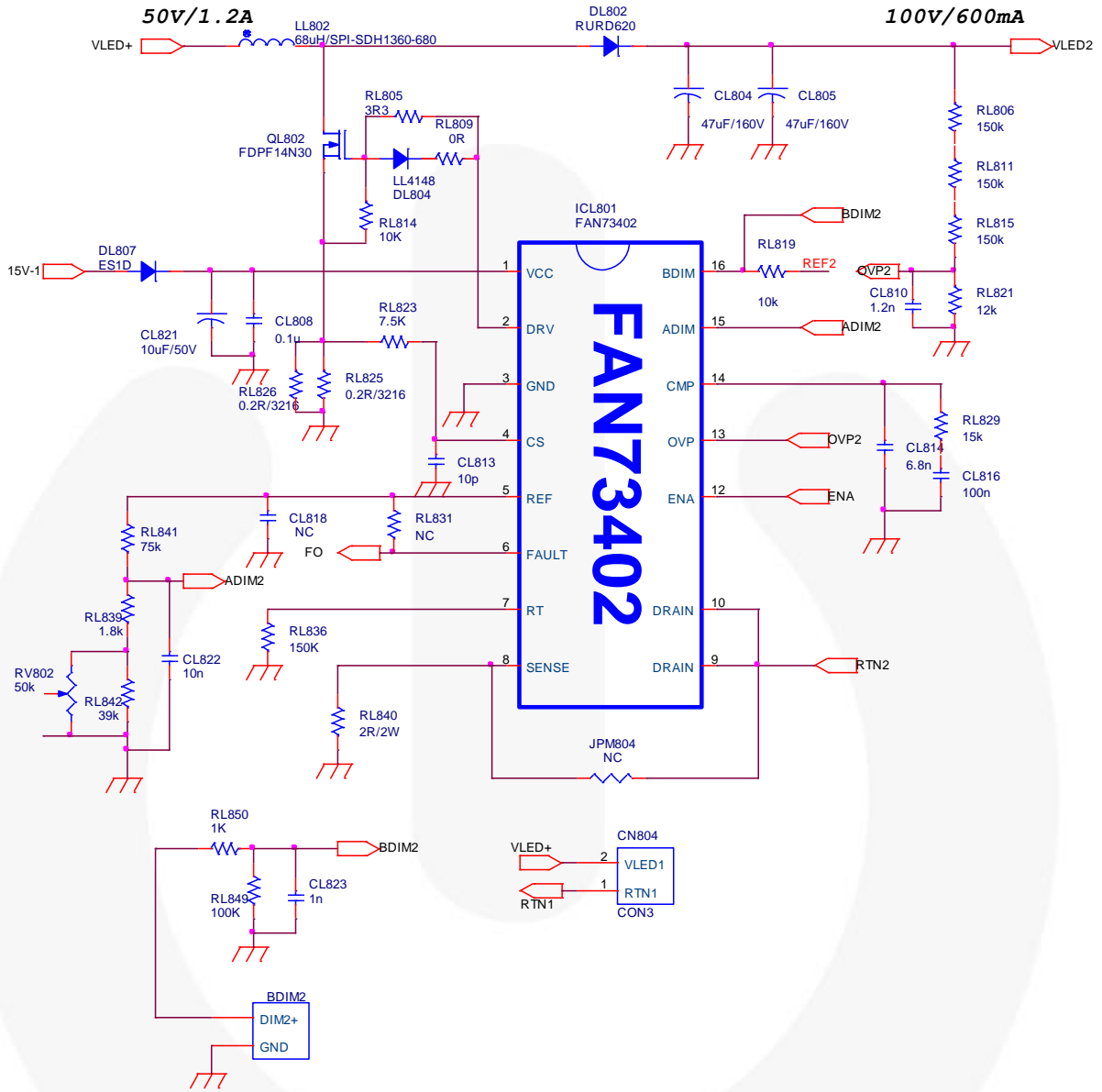


Figure 13. Schematic for Boost Channel 2

## 6. Bill of Materials

| No. | Part Reference  | Part Value            | Qty. | Description              | Vendor   |
|-----|---|-----------------------|------|--------------------------|----------|
| 1   | BDIM1, BDIM2  | 2 Pin                 | 1    | 2 Pin Connector          | Molex    |
| 2   | CL801, CL802, CL804, CL805  | 47 $\mu$ F/160 V      | 4    | Electrolytic Capacitor   | Samyoung |
| 3   | CL803, CL809, CL810   | C0805C112J5GACTU      | 3    | 1.2 nF/50 V, SMD MLCC    | Kemet    |
| 4   | CL806, CS808, CS814, CL821  | KMG 10 $\mu$ F/35 V   | 4    | Electrolytic Capacitor   | Samyoung |
| 5   | CP806, CS807, CL807, CS809, CS810, CS811, CM811, CS812, CS815, CL815, CL816, CM818, CL808 | C0805C104J5GACTU      | 13   | 1.2 nF/50 V, SMD MLCC    | Kemet    |
| 6   | CL811, CL813, CM814   | C0805C100J5GACTU      | 3    | 10 pF/50 V, SMD MLCC     | Kemet    |
| 7   | CL812, CL814  | C0805C683J5GACTU      | 2    | 6.8 nF/50 V, SMD MLCC    | Kemet    |
| 8   | CM807, CM810, CL819, CL822  | C0805C103J5GACTU      | 4    | 10 nF/50 V, SMD MLCC     | Kemet    |
| 9   | CP809, CP811, CL820, CL823  | C0805C102J5GACTU      | 4    | 1 nF/50 V, SMD MLCC      | Kemet    |
| 10  | CM801, CM802, CM803, CM804  | NHL 330 $\mu$ F/250V  | 4    | Electrolytic Capacitor   | Samyoung |
| 11  | CM806   | C0805C224J5GACTU      | 1    | 220 nF/50 V, SMD MLCC    | Kemet    |
| 12  | CM808   | C0805C474J5GACTU      | 1    | 470 nF/50 V, SMD MLCC    | Kemet    |
| 13  | CM809   | C0805C473J5GACTU      | 1    | 47 nF/50 V, SMD MLCC     | Kemet    |
| 14  | CM816   | 4.7 nF/630 V          | 1    | Film Capacitor           | Sungho   |
| 15  | CM817, CM820  | C0805C822J5GACTU      | 2    | 8.2 nF/50 V, SMD MLCC    | Kemet    |
| 16  | CM823   | C0805C562J5GACTU      | 1    | 5.6 nF/50 V, SMD MLCC    | Kemet    |
| 17  | CM824   | C1206C473J1GACTU      | 1    | 47 nF/100 V, SMD MLCC    | Kemet    |
| 18  | CN801   | 3 Pin                 | 1    | 3 Pin Connector          | Molex    |
| 19  | CN802, CN803, CN804, CN805  | 2 Pin                 | 4    | 2 Pin Connector          | Molex    |
| 20  | CP801, CP802  | KMG 330 $\mu$ F/250 V | 2    | Electrolytic Capacitor   | Samyoung |
| 21  | CP803   | 680 n/630 V           | 1    | Film Capacitor           | Sungho   |
| 22  | CP805, CM812, CS813   | KMG 10 $\mu$ F/35 V   | 3    | Electrolytic Capacitor   | Samyoung |
| 23  | CP807   | C0805C204J5GACTU      | 1    | 200 nF/50 V, SMD MLCC    | Kemet    |
| 24  | CP808   | C0805C105J5GACTU      | 1    | 1 $\mu$ F/50 V, SMD MLCC | Kemet    |
| 25  | CS802   | C1206C202J5GACTU      | 1    | 2.2 nF/630 V, SMD MLCC   | Kemet    |
| 26  | CS803   | KMG 47 $\mu$ F/35 V   | 1    | Electrolytic Capacitor   | Samyoung |
| 27  | CS804   | KMG 470 $\mu$ F/35 V  | 1    | Electrolytic Capacitor   | Samyoung |

| No. | Part Reference   | Part Value                 | Qty. | Description                    | Vendor                  |
|-----|--|----------------------------|------|--------------------------------|-------------------------|
| 28  | CS806  | C1206C823J5GACTU           | 1    | 82 nF/50 V, SMD MLCC           | Kemet                   |
| 29  | CX801, CX802   | MPX334                     | 2    | X-Capacitor                    | Carli                   |
| 30  | CY801, CY802   | SDC471J10FS10              | 2    | Y-Capacitor                    | Samwha                  |
| 31  | CY803, CY806   | SDC472J10FK7               | 1    | Y-Capacitor                    | Samwha                  |
| 32  | DL801, DL802   | RURD620                    | 2    | 200 V/6 A Ultrafast Diode      | Fairchild Semiconductor |
| 33  | DM803, DL803, DP804, DL804, DM805, DL805, DM806, DM807, DM808, DM809 | LL4148                     | 10   | Small Signal Diode             | Fairchild Semiconductor |
| 34  | DS801, DP803, DL806, DL807, DM810                                    | ES1D                       | 5    | 200 V/1 A, Ultra-Fast Diode    | Fairchild Semiconductor |
| 35  | DM801, DM802   | MBR20200CT                 | 2    | 200 V/20 A, Schottky Rectifier | Fairchild Semiconductor |
| 36  | DM804  | UF4004                     | 1    | 400 V/1.0 A, Ultra-Fast Diode  | Fairchild Semiconductor |
| 37  | DP801  | 1N5408                     | 1    | 1000 V/3 A, General Rectifier  | Fairchild Semiconductor |
| 38  | DP802  | FFPF08H60S                 | 1    | 8 A, 600 V, Hyper-Fast Diode   | Fairchild Semiconductor |
| 39  | DS802  | RS1M                       | 1    | 1000 V/1 A, Ultra-Fast Diode   | Fairchild Semiconductor |
| 40  | DS803  | SB560                      | 1    | 60 V/5 A, Schottky Rectifier   | Fairchild Semiconductor |
| 41  | DS804  | 1N4003                     | 1    | Ultra-Fast Diode               | Fairchild Semiconductor |
| 42  | DX801  | D15XB60                    | 1    | 600 V 15 A, Bridge Diode       | Shindengen              |
| 43  | FS801  | SS-5-3.15 A                | 1    | 250 V/3.15 A, Fuse             | Bussmann                |
| 44  | HS1  | 150 mm                     | 1    | Heat Sink [Primary]            |                         |
| 45  | HS2  | 50 mm                      | 1    | Heat Sink [Secondary]          |                         |
| 46  | ICL801, ICL802   | FAN73402                   | 2    | LED Boost Switch               | Fairchild Semiconductor |
| 47  | ICM801   | FAN7631                    | 1    | LLC Controller                 | Fairchild Semiconductor |
| 48  | ICM803   | TSM103W                    | 1    | Dual OP-Amp                    | ST                      |
| 49  | ICP801   | FL7930C                    | 1    | PFC Controller                 | Fairchild Semiconductor |
| 50  | ICS802   | FSL117MRIN                 | 1    | Green Mode FPS                 | Fairchild Semiconductor |
| 51  | ICS803   | KA431SMF2TF                | 1    | Shunt Regulator                | Fairchild Semiconductor |
| 52  | ICS804, ICS805   | KA78L15                    | 2    | 15 V Voltage Regulator         | Fairchild Semiconductor |
| 53  | JPM805   | JUMPER                     | 1    | Jumper                         | Molex                   |
| 54  | LL801, LL802   | 68 $\mu$ H/SPI-SDH1360-680 | 2    | 68 $\mu$ H, SMD Inductor       | TDK                     |

| No. | Part Reference  | Part Value        | Qty. | Description                                       | Vendor                  |
|-----|---|-------------------|------|---|-------------------------|
| 55  | LP801   | PFC3819QM         | 1    | 300 $\mu$ H, PFC Inductor                         | TDK                     |
| 56  | LX801, LX802  | CV630055          | 2    | Line Filter                                       | TNC                     |
| 57  | PCM801, PCS801, PCS802  | FOD817B           | 3    | Opto-Coupler                                      | Fairchild Semiconductor |
| 58  | QL801, QL802  | FDPF14N30         | 2    | 300 V/14 A MOSFET                                 | Fairchild Semiconductor |
| 59  | QM801, QM802  | FCPF600N60Z       | 2    | 600 V/R <sub>DS(on)</sub> :0.19 $\Omega$ , MOSFET | Fairchild Semiconductor |
| 60  | QP802   | FCPF190N60E       | 1    | 600 V/R <sub>DS(on)</sub> :0.6 $\Omega$ , MOSFET  | Fairchild Semiconductor |
| 61  | QS801, QS853  | KSPT2907A         | 2    | PNP Transistor                                    | Fairchild Semiconductor |
| 62  | QS802, QS803, QS854   | KST2222AMTF       | 3    | NPN Transistor                                    | Fairchild Semiconductor |
| 63  | RL801, RL802, RL804, RL806, RL808, RL811, RL815, RL835, RL836, RL813        | RC0805JR-07150KL  | 10   | 150 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 64  | RL803, RL805  | RC0805JR-073R3L   | 2    | 3.3 $\Omega$ , 2012 SMD                           | Yageo                   |
| 65  | RL807, RL809, JPM801, JPM802, RS812   | RC0805JR-070RL    | 5    | 0 $\Omega$ , 2012 SMD                             | Yageo                   |
| 66  | RL810   | RC0805JR-079k1L   | 1    | 9.1 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 67  | RP805, RM809, RP812, RL812, RL814, RL818, RL819, RM823, RM839, RS855, RS858 | RC0805JR-0710kL   | 11   | 10 k $\Omega$ , 2012 SMD                          | Yageo                   |
| 68  | RL816, RL817, RL825, RL826  | RC1206JR-070R2L   | 4    | 0.2 $\Omega$ , 3216 SMD                           | Yageo                   |
| 69  | RS811, RL820, RL821, RM830  | RC0805JR-0712kL   | 4    | 12 k $\Omega$ , 2012 SMD                          | Yageo                   |
| 70  | RL822 RL823   | RC0805JR-077k5L   | 2    | 7.5 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 71  | RM828, RL828, RL829, RS856, RS857   | RC0805JR-0715kL   | 5    | 15 k $\Omega$ , 2012 SMD                          | Yageo                   |
| 72  | RL832, RL841  | RC0805JR-0775kL   | 2    | 75 k $\Omega$ , 2012 SMD                          | Yageo                   |
| 73  | RL834, RL839  | RC0805JR-071k8L   | 2    | 1.8 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 74  | RL837, RL840  | 2 $\Omega$ /2 W   | 2    | 2 $\Omega$ , 2 W Resistor                         | Abel                    |
| 75  | RM827, RL838, RM841, RL842  | RC0805JR-0739kL   | 4    | 39 k $\Omega$ , 2012 SMD                          | Yageo                   |
| 76  | RS808, RS815, RM826, RL847, RL850   | RC0805JR-071kL    | 5    | 1 k $\Omega$ , 2012 SMD                           | Yageo                   |
| 77  | RM821, RL848, RL849   | RC0805JR-07100kL  | 3    | 100 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 78  | RM801, RM802  | 0.2 $\Omega$ /1 W | 2    | 0.2 $\Omega$ , 1 W Resistor                       | Abel                    |
| 79  | RM803   | RC0805FR-0727kL   | 1    | 27 k $\Omega$ /F, 2012 SMD                        | Yageo                   |
| 80  | RM805   | RC0805JR-071ML    | 1    | 1 M $\Omega$ , 2012 SMD                           | Yageo                   |
| 81  | RM806   | RC0805JR-071k1L   | 1    | 1.1 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 82  | RM807   | RC0805FR-0724kL   | 1    | 24 k $\Omega$ /F, 2012 SMD                        | Yageo                   |
| 83  | RM808, RM813  | RC0805JR-072M2L   | 2    | 2.2M $\Omega$ , 2012 SMD                          | Yageo                   |
| 84  | RM810   | RC0805FR-072k7L   | 1    | 2.7 k $\Omega$ /F, 2012 SMD                       | Yageo                   |
| 85  | RM811, RS814  | RC0805JR-074k7L   | 2    | 4.7 k $\Omega$ , 2012 SMD                         | Yageo                   |
| 86  | RM812, RM822, RP815   | RC0805JR-073R3L   | 3    | 3.3 $\Omega$ , 2012 SMD                           | Yageo                   |
| 87  | RM814   | RC0805JR-075k6L   | 1    | 5.6 k $\Omega$ , 2012 SMD                         | Yageo                   |

| No. | Part Reference                                | Part Value       | Qty. | Description              | Vendor     |
|-----|---|------------------|------|--------------------------|------------|
| 88  | RM817   | RC1206JR-0710RL  | 1    | 10 Ω, 2012 SMD           | Yageo      |
| 89  | RM820   | RC0805JR-0724kL  | 1    | 24 kΩ, 2012 SMD          | Yageo      |
| 90  | RM825   | RC1206JR-071KL   | 1    | 1 kΩ, 3216 SMD           | Yageo      |
| 91  | RS816, RS817, RS818, RS819,<br>RS820, RM829   | RC0805JR-0720kL  | 6    | 20 kΩ, 2012 SMD          | Yageo      |
| 92  | RS809, RM832, RM838                           | RC0805JR-075k1L  | 3    | 5.1 kΩ, 2012 SMD         | Yageo      |
| 93  | RM833, RM840                                  | RC1206JR-0718kL  | 2    | 18 kΩ, 2012 SMD          | Yageo      |
| 94  | RM836   | RC0805JR-072k2L  | 1    | 2.2 kΩ, 2012 SMD         | Yageo      |
| 95  | RM837   | RC0805FR-0710kL  | 1    | 10 kΩ/F, 2012 SMD        | Yageo      |
| 96  | RM840   | RC0805FR-072k2L  | 1    | 2.2 kΩ/F, 2012 SMD       | Yageo      |
| 97  | RP801, RP804, RP807, RP809                    | RC0805JR-074M3L  | 4    | 4.3 MΩ, 2012 SMD         | Yageo      |
| 98  | RP803   | RC0805JR-0710RL  | 1    | 10 Ω, 2012 SMD           | Yageo      |
| 99  | RP806   | RC0805JR-0747kL  | 1    | 47 kΩ, 2012 SMD          | Yageo      |
| 100 | RP811   | RC0805JR-07150L  | 1    | 150 Ω, 2012 SMD          | Yageo      |
| 101 | RP813   | RC0805JR-0791kL  | 1    | 91 kΩ, 2012 SMD          | Yageo      |
| 102 | RP814   | 0.1 Ω/5 W        | 1    | 0.1 Ω, 5 W Resistor      | Abel       |
| 103 | RP816   | RC0805JR-074K7L  | 1    | 4.7 kΩ, 2012 SMD         | Yageo      |
| 104 | RS804, RS805                                  | RC1206JR-07100kL | 2    | 100 kΩ, 3216 SMD         | Yageo      |
| 105 | RS806, RS821, RS822, RS823                    | RC1206JR-0730kL  | 4    | 30 kΩ, 3216 SMD          | Yageo      |
| 106 | RS807   | RC1206JR-070RL   | 1    | 0 Ω, 3216 SMD            | Yageo      |
| 107 | RS810   | RC0805JR-071k5L  | 1    | 1.5 kΩ, 2012 SMD         | Yageo      |
| 108 | RS824, RS835                                  | RC1206JR-07120L  | 1    | 390 Ω, 3216 SMD          | Yageo      |
| 109 | RT1, RT2                                      | 3D15             | 2    | NTC Thermistor           | Daekwang S |
| 110 | RV801, RV802                                  | 50 kΩ/0.5 W      | 2    | 50 kΩ, Variable Resistor | Vishay     |
| 111 | RX801, RX802, RX803                           | RC1206JR-071ML   | 3    | 1 MΩ, 3216 SMD           | Yageo      |
| 112 | SW1   | Toggle Switch    | 1    | 3 Terminal Switch        | Phonix     |
| 113 | TM801   | SRX43EM          | 1    | LLC Transformer          | TDK        |
| 114 | TS801   | EPC1717          | 1    | LLC Transformer          | TDK        |
| 115 | ZNR801  | 10D561K          | 1    | MOV                      | Samwha     |
| 116 | CL817, CL818, CM805, CS805                    | NC               | 4    |                          |            |
| 117 | RS813, RP817, JPM803, JPM804,<br>RL830, RL831 | NC               | 6    |                          |            |
| 118 | ZDP801  | NC               | 1    |                          |            |

## 7. Transformer Design

### 7.1. Flyback Transformer (TS801)

- Core: EPC1717 (TDK)
- Bobbin: 10 Pin

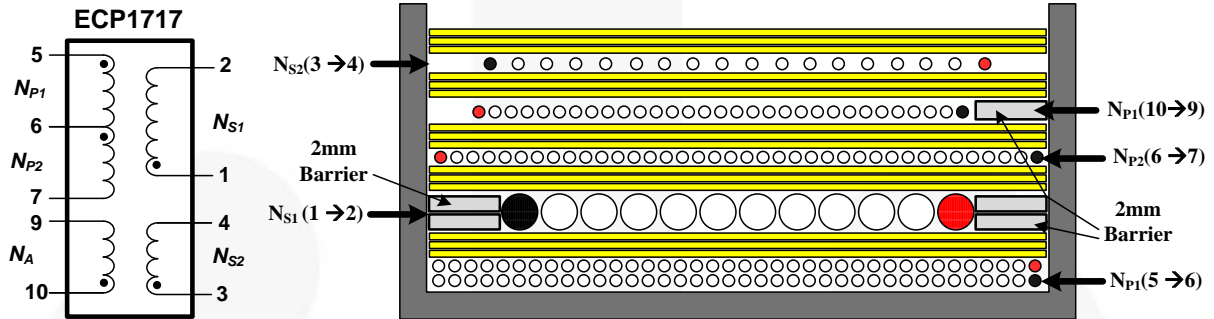


Figure 14. Transformer Pin Assignment and Configuration

Table 2. Winding Specifications

| No. | Winding  | Pin (S → F) | Wire  | Turns  | Winding Method   |
|-----|--|-------------|-------|--------|------------------|
| 1   | $N_{P1}$   | 5 → 6       | 0.15φ | 100 Ts | Solenoid Winding |
| 2   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |       |        |                  |
| 3   | $N_{S1}$   | 1 → 2       | 0.45φ | 12 Ts  | Solenoid Winding |
| 4   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |       |        |                  |
| 5   | $N_{P2}$   | 6 → 7       | 0.25φ | 44 Ts  | Solenoid Winding |
| 6   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |       |        |                  |
| 7   | $N_A$  | 10 → 9      | 0.15φ | 37 Ts  | Solenoid Winding |
| 8   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |       |        |                  |
| 9   | $N_{S2}$   | 3 → 4       | 0.25φ | 22 Ts  | Solenoid Winding |
| 10  | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |       |        |                  |

Table 3. Electrical Characteristics

|                 | Pin   | Specifications | Remark                               |
|-----------------|-------|----------------|--------------------------------------|
| Inductance [Lp] | 5 – 7 | 900 μH ±10%    | 60 kHz, 1 V                          |
| Leakage [LI]    | 5 – 7 | 55 μH          | 60 kHz, 1 V at Short All Output Pins |



## 7.2. PFC Inductor (LP801)

- Core: PFC3819QM(TDK)
- Bobbin: PQM3819, 8 Pin

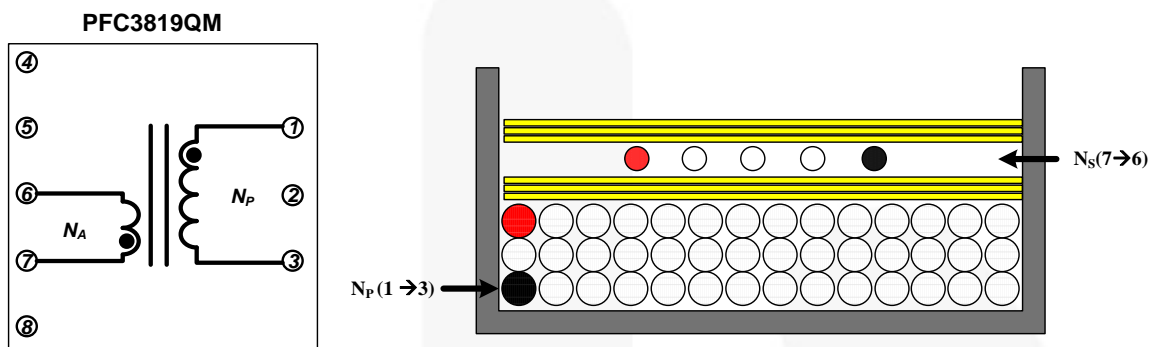


Figure 15. Transformer Pin Assignment and Configuration

Table 4. Winding Specifications

| No. | Winding  | Pin (S → F) | Wire         | Turns | Winding Method   |
|-----|--|-------------|--------------|-------|------------------|
| 1   | $N_p$  | 1 → 3       | 0.1*65[Litz] | 40 Ts | Solenoid Winding |
| 2   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |              |       |                  |
| 3   | $N_{S1}$   | 7 → 6       | 0.45φ        | 4 Ts  | Solenoid Winding |
| 4   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |              |       |                  |

Table 5. Electrical Characteristics

|            | Pin   | Specifications        | Remark      |
|------------|-------|-----------------------|-------------|
| Inductance | 1 – 3 | 300 $\mu$ H $\pm$ 10% | 60 kHz, 1 V |

### 7.3. LLC Transformer (TM801)

- Core: SRX43EM (TDK)
- Bobbin: EEX4333P12-1, 12 Pin

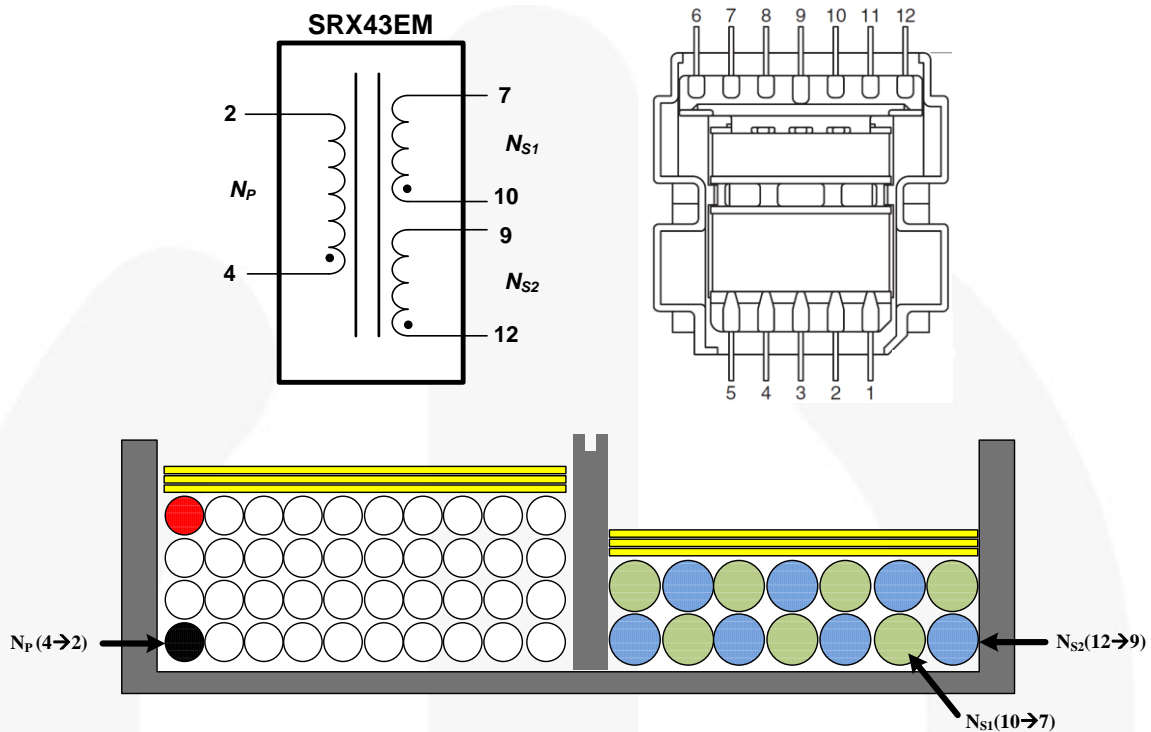


Figure 16. Transformer Pin Assignment and Configuration

Table 6. Winding Specifications

| No. | Winding  | Pin (S → F) | Wire                | Turns | Winding Method   |
|-----|--|-------------|---------------------|-------|------------------|
| 1   | $N_P$  | 4 → 2       | 0.1φ * 60 [Litz]]   | 37 Ts | Solenoid Winding |
| 2   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |                     |       |                  |
| 3   | $N_{S1}$   | 12 → 9      | 0.08 φ * 120[Litz]] | 7 Ts  | Solenoid Winding |
|     | $N_{S2}$   | 10 → 7      |                     | 7 Ts  | Solenoid Winding |
| 4   | Insulation: Polyester Tape t = 0.025 mm, 3-Layer |             |                     |       |                  |

Table 7. Electrical Characteristics

|                 | Pin   | Specifications | Remark                              |
|-----------------|-------|----------------|-------------------------------------|
| Inductance [Lp] | 4 – 2 | 810 μH ±10%    | 100 kHz, 1 V                        |
| Leakage [Lr]    | 5 – 7 | 105 μH         | Short One of the Secondary Windings |

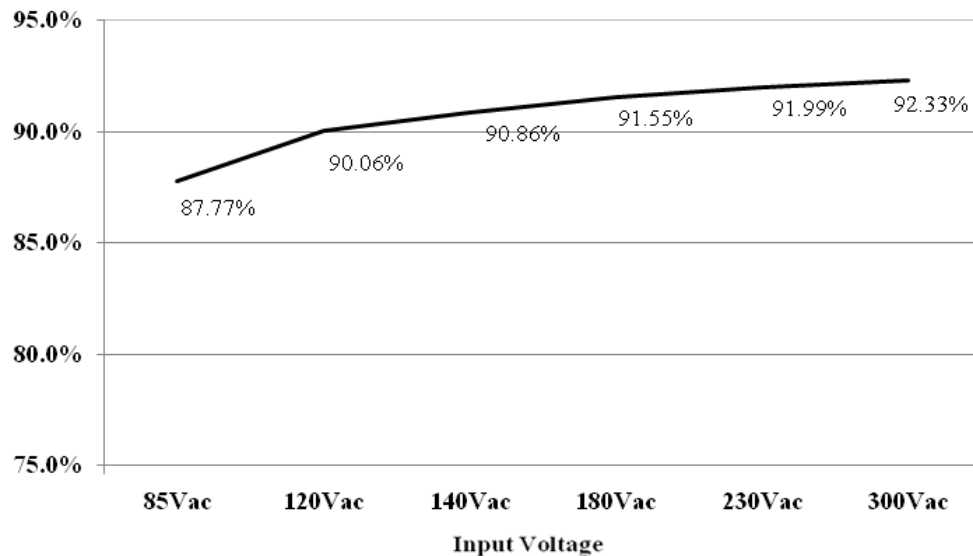
## 8. Performance of Evaluation Board

**Table 8. Test Condition & Equipments**

| Ambient Temperature | $T_A = 25^\circ\text{C}$   |
|---------------------|--|
| Test Equipment      | AC Power Source: PCR500L by Kikusui<br>Power Analyzer: PZ4000000 by Yokogawa<br>Electronic Load: PLZ303WH by KIKUSUI<br>Multi Meter: 2002 by KEITHLEY, 45 by FLUKE<br>Oscilloscope: 104Xi by LeCroy<br>Thermometer: Thermal CAM SC640 by FLIR SYSTEMS<br>LED: EHP-AX08EL/GT01H-P03 (3W) by Everlight |

### 8.1. System Efficiency

System efficiency is measured in 85 ~ 140 V<sub>AC</sub> [low line, 60 Hz] and 180 ~ 300 V<sub>AC</sub> [high line, 50 Hz] input voltage ranges. The results are for PFC and LLC converters in which a single LED channel can be connected and measured in the rated load condition [50 V/2.5 A] 30 minutes after AC power is turned on.



**Figure 17. System Efficiency**

**Table 9. System Efficiency**

| Input Voltage               | Output Voltage[V] | Output Current [A] | Input Power [W] | Output Power [W] | Efficiency |
|-----------------------------|-------------------|--------------------|-----------------|------------------|------------|
| 85 V <sub>AC</sub> [60 Hz]  | 49.69             | 2.503              | 141.70          | 124.37           | 87.77%     |
| 120 V <sub>AC</sub> [60 Hz] | 49.69             | 2.503              | 138.10          | 124.37           | 90.06%     |
| 140 V <sub>AC</sub> [60 Hz] | 49.69             | 2.507              | 137.10          | 124.57           | 90.86%     |
| 180 V <sub>AC</sub> [50 Hz] | 49.69             | 2.502              | 135.80          | 124.32           | 91.55%     |
| 230 V <sub>AC</sub> [50 Hz] | 49.69             | 2.503              | 135.20          | 124.37           | 91.99%     |
| 300 V <sub>AC</sub> [50 Hz] | 49.69             | 2.501              | 134.60          | 124.27           | 92.33%     |

System efficiency is measured in 85 ~ 140 V<sub>AC</sub> [low line, 60 Hz] and 180 ~ 300 V<sub>AC</sub> [high line, 50Hz] input voltage ranges. The results are for PFC and LLC converters in which a single LED channel can be connected and measured in the 50% load condition [50 V/1.25 A] 30 minutes after AC power is turned on.

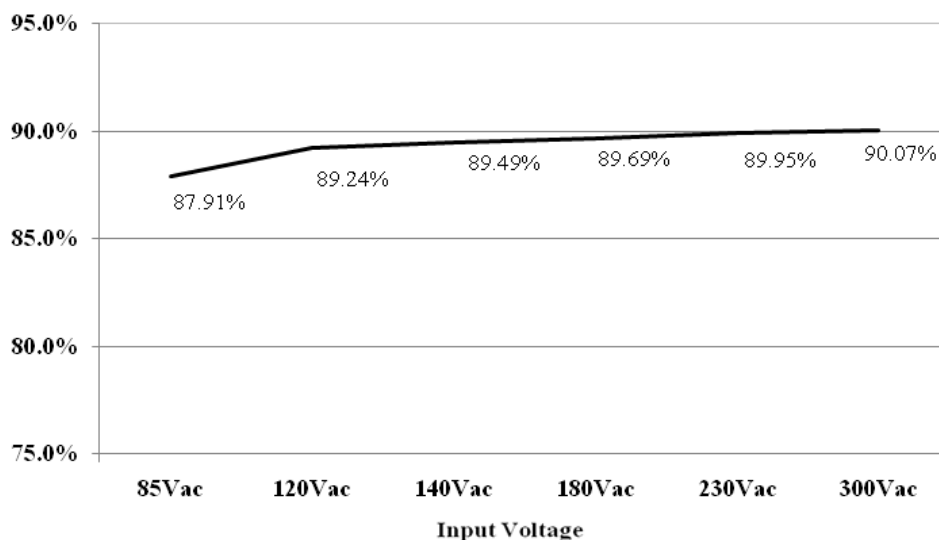


Figure 18. System Efficiency

Table 10. System Efficiency

| Input Voltage               | Output Voltage[V] | Output Current [A] | Output Voltage [V] | Output Power [W] | Efficiency |
|-----------------------------|-------------------|--------------------|--------------------|------------------|------------|
| 85 V <sub>AC</sub> [60 Hz]  | 49.71             | 1.252              | 70.80              | 62.24            | 87.91%     |
| 120 V <sub>AC</sub> [60 Hz] | 49.71             | 1.253              | 69.80              | 62.29            | 89.24%     |
| 140 V <sub>AC</sub> [60 Hz] | 49.71             | 1.253              | 69.60              | 62.29            | 89.49%     |
| 180 V <sub>AC</sub> [50 Hz] | 49.71             | 1.254              | 69.50              | 62.34            | 89.69%     |
| 230 V <sub>AC</sub> [50 Hz] | 49.71             | 1.254              | 69.30              | 62.34            | 89.95%     |
| 300 V <sub>AC</sub> [50 Hz] | 49.71             | 1.252              | 69.10              | 62.24            | 90.07%     |

Table 11 shows stand-by power consumption of 85 V<sub>AC</sub>~ 140 V<sub>AC</sub> [low line, 60 Hz] and 180 ~ 300 V<sub>AC</sub> [high line, 50 Hz] input voltage ranges. The results are measured when the PS-ON switch is turned off.

Table 11. System Efficiency

| Input Voltage               | Input Power [W] |
|-----------------------------|-----------------|
| 85 V <sub>AC</sub> [60 Hz]  | 0.283           |
| 120 V <sub>AC</sub> [60 Hz] | 0.306           |
| 140 V <sub>AC</sub> [60 Hz] | 0.315           |
| 180 V <sub>AC</sub> [50 Hz] | 0.319           |
| 230 V <sub>AC</sub> [50 Hz] | 0.341           |
| 300 V <sub>AC</sub> [50 Hz] | 0.397           |

## 8.2. Power Factor and Total Harmonic Discharge (THD)

Power factor and THD were measured in 85 ~ 140 V<sub>AC</sub> [low line, 60 Hz] and 180 ~ 300 V<sub>AC</sub> [high line, 50 Hz] input voltage ranges. The measured data were results for the overall system with two channel LED loads connected.

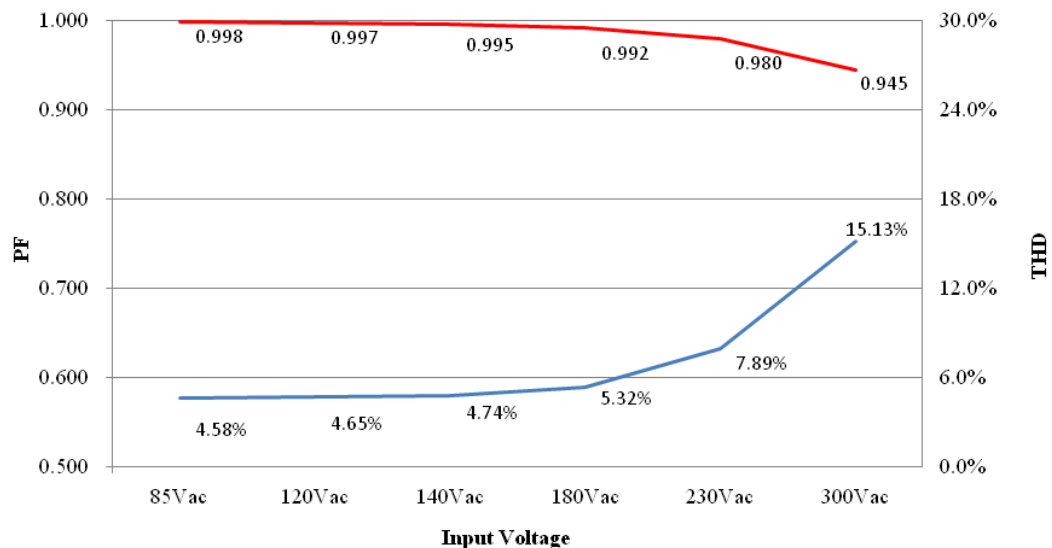


Figure 19. Power Factor & Total Harmonic Distortion

Table 12. Power Factor & Total Harmonic Distortion

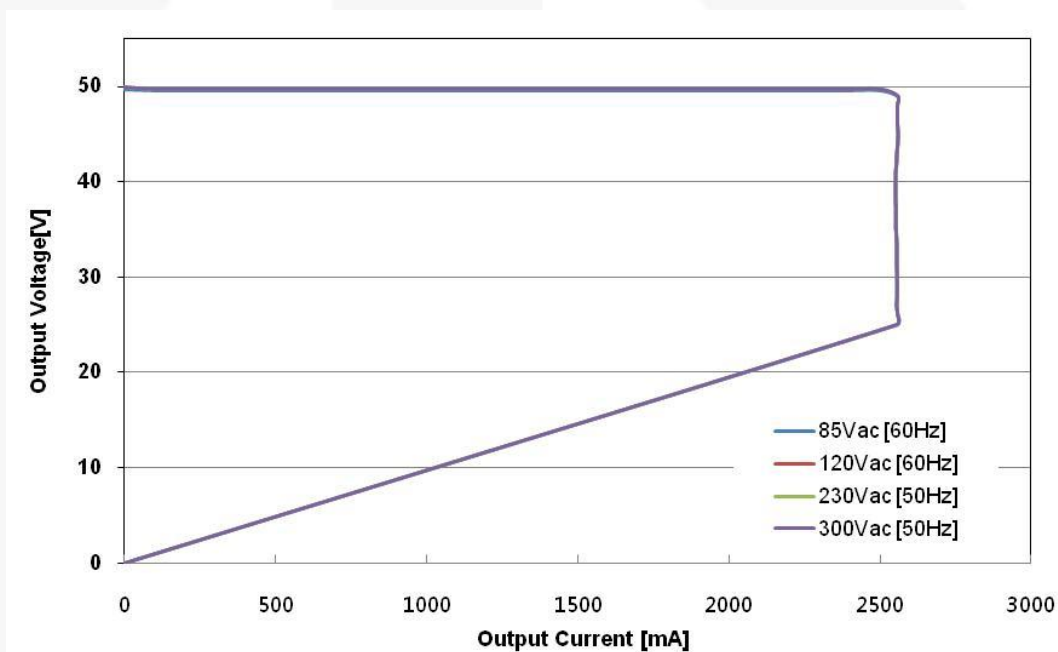
| Input Voltage               | Output Current | Output Voltage | Power Factor | THD    |
|-----------------------------|----------------|----------------|--------------|--------|
| 85 V <sub>AC</sub> [60 Hz]  | 2.503 A        | 49.69 V        | 0.998        | 4.58%  |
| 120 V <sub>AC</sub> [60 Hz] | 2.503 A        | 49.69 V        | 0.997        | 4.65%  |
| 140 V <sub>AC</sub> [60 Hz] | 2.507 A        | 49.69 V        | 0.995        | 4.74%  |
| 180 V <sub>AC</sub> [50 Hz] | 2.502 A        | 49.69 V        | 0.992        | 5.32%  |
| 230 V <sub>AC</sub> [50 Hz] | 2.503 A        | 49.69 V        | 0.980        | 7.89%  |
| 300 V <sub>AC</sub> [50 Hz] | 2.501 A        | 49.69 V        | 0.945        | 15.13% |

### 8.3. Constant-Current and Voltage Regulation

Table 13 and Figure 20 show the typical CC/CV performance on the board; showing very stable CC performance over a wide input range. The results are for PFC and LLC converters with a single LED channel connected and measured with E-Load [CR Mode].

**Table 13. Constant-Current Regulation by Output Voltage Change (25 V~ 50 V)**

| Input Voltage               | Min.                 |                       | Max.                 |                       | CV     | CC     |
|-----------------------------|----------------------|-----------------------|----------------------|-----------------------|--------|--------|
|                             | V <sub>OUT</sub> [V] | I <sub>OUT</sub> [mA] | V <sub>OUT</sub> [V] | I <sub>OUT</sub> [mA] |        |        |
| 85 V <sub>AC</sub> / 60 Hz  | 49.60                | 2552                  | 49.70                | 2560                  | ±0.03% | ±0.04% |
| 120 V <sub>AC</sub> / 60 Hz | 49.60                | 2552                  | 49.70                | 2560                  | ±0.03% | ±0.04% |
| 230 V <sub>AC</sub> / 50 Hz | 49.70                | 2552                  | 49.90                | 2560                  | ±0.05% | ±0.04% |
| 300 V <sub>AC</sub> / 50 Hz | 49.70                | 2552                  | 49.90                | 2560                  | ±0.05% | ±0.04% |



**Figure 20. Constant-Current Regulation, Measured by E-Load [CR Mode]**

## 8.4. Overall Startup Performance

Figure 21 and Figure 22 show the startup performance; including flyback, boost, LLC resonant converter, and single-channel boost converter at rated output load. The output load current starts flowing after about 469 ms and 340 ms for input voltage 85 V<sub>AC</sub> and 300 V<sub>AC</sub> condition when the AC input power switch turns on; CH1: V<sub>DD\_Flyback</sub> (10 V / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>LED</sub> (50 V / div), CH4: I<sub>LED</sub> (0.5 A / div), Time Scale: 200 ms / div.



Figure 21. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz

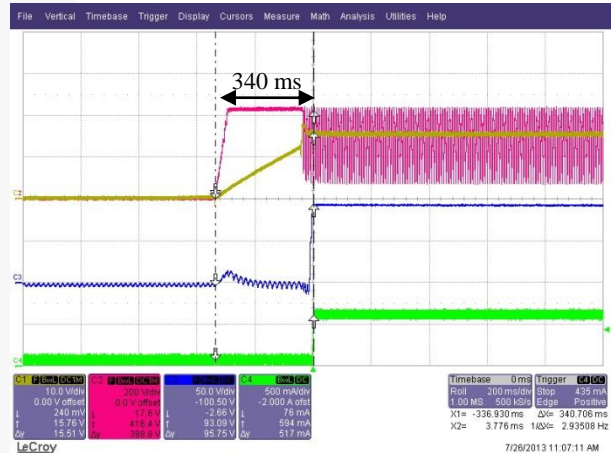


Figure 22. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz

Figure 23 and Figure 24 show the startup and stop performance for the PS-ON switch operation; including boost, LLC resonant converter, and single-channel boost converter. The output load current starts flowing about 59 ms after the PS-ON switch was turned on and is disconnected when the PS-ON switch was turned off in standby status; CH1: V<sub>DD\_PFC</sub> (10 V / div), CH2: V<sub>PS-ON</sub> (2 V / div), CH3: V<sub>LED</sub> (50 V / div), CH4: I<sub>LED</sub> (0.5 A / div).

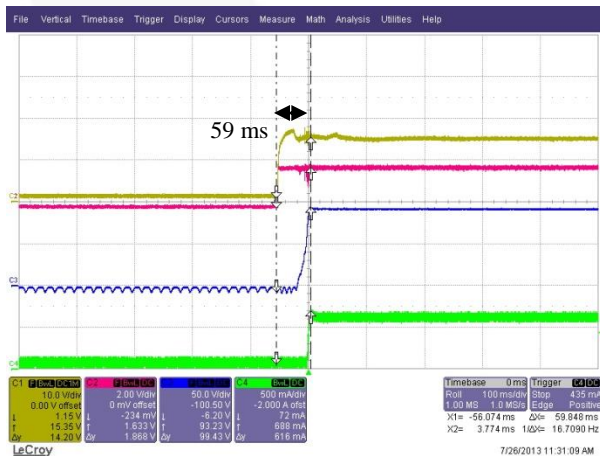


Figure 23. PS-ON [100 ms/div]

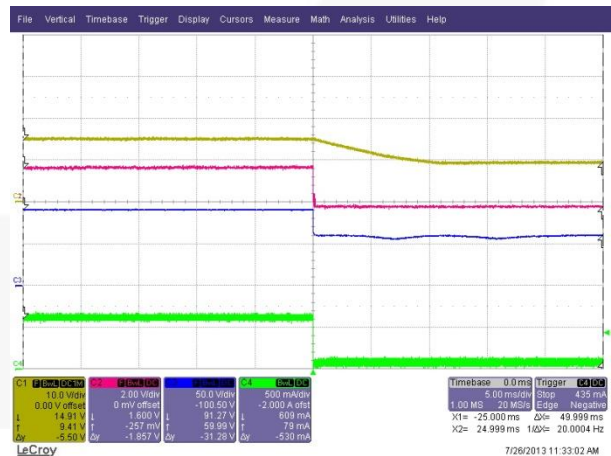


Figure 24. PS-OFF [5 ms/div]

## 8.5. Startup Performance in Flyback Stage

Figure 25 and Figure 26 show the startup performance of the flyback converter. The output voltage is raised after about 395 ms and 297 ms at 85 V<sub>AC</sub> and 300 V<sub>AC</sub> input voltage, respectively, when the AC input power switch turns on; CH1: V<sub>DD-FLYBACK</sub> (10 V / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>SV</sub> (2 V / div), CH4: V<sub>DD-FAN73402</sub> (10 V / div), Time Scale: 200 ms / div.

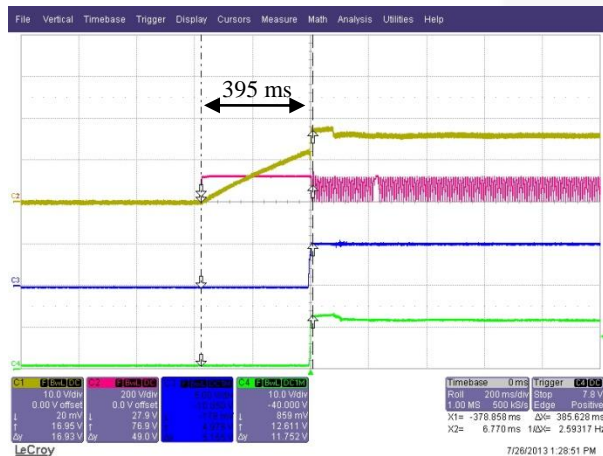


Figure 25. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz

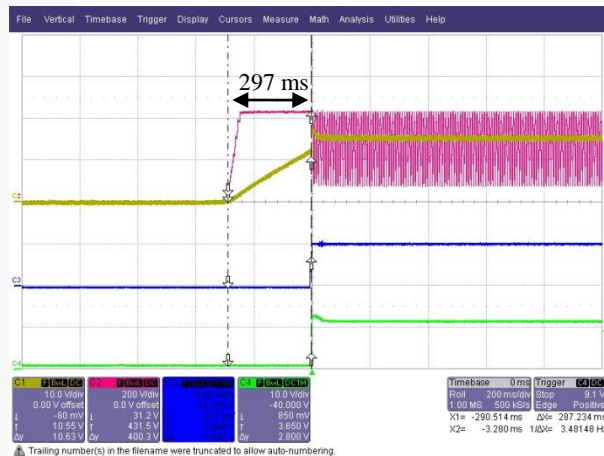


Figure 26. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz

Figure 27 and Figure 28 show the startup and stop performance for the flyback converter according to PS-ON switch operation. Each output voltage is raised at the same time when the PS-ON switch is turned on and V<sub>DD-FAN73402</sub> drops under UVLO after 100 ms since PS-ON switch was turned off in standby status; CH1: V<sub>DD-PFC</sub> (10 V / div), CH2: V<sub>PS-ON</sub> (2 V / div), CH3: V<sub>SV</sub> (2 V / div), CH4: V<sub>DD-FAN73402</sub> (10 V / div), Time Scale: 200 ms / div.

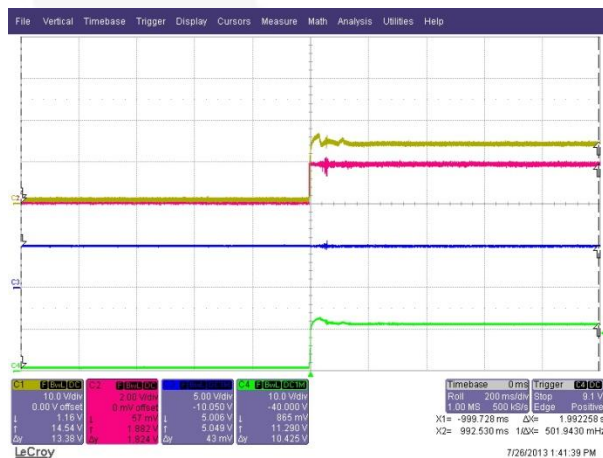


Figure 27. PS-ON

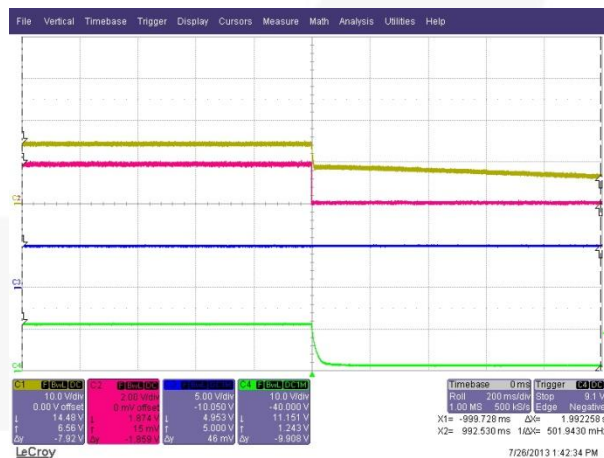


Figure 28. PS-OFF



## 8.6. Startup Performance in PFC Stage

Figure 29 and Figure 30 show the startup performance; including flyback and boost converter at the rated output load. The PFC output voltage is raised after about 429 ms and 339 ms, respectively, for input voltage 85 V<sub>AC</sub> and 300 V<sub>AC</sub> condition when the AC input power switch turns on; CH1: V<sub>DD-FLYBACK</sub> (10 V / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>OUT\_PFC</sub> (200 V / div), CH4: V<sub>R<sub>RDY</sub></sub> (2 V / div), Time Scale: 200 ms / div.

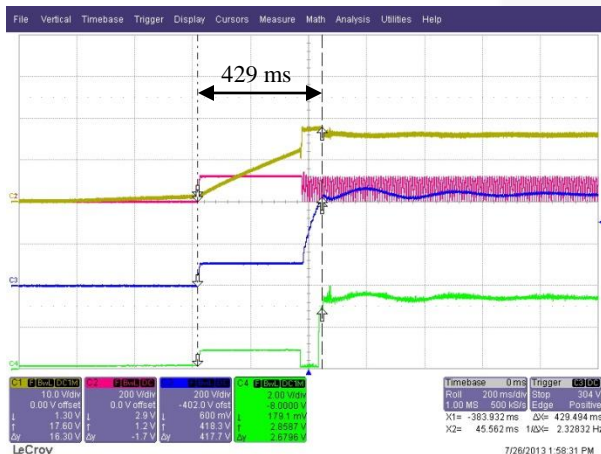


Figure 29. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz

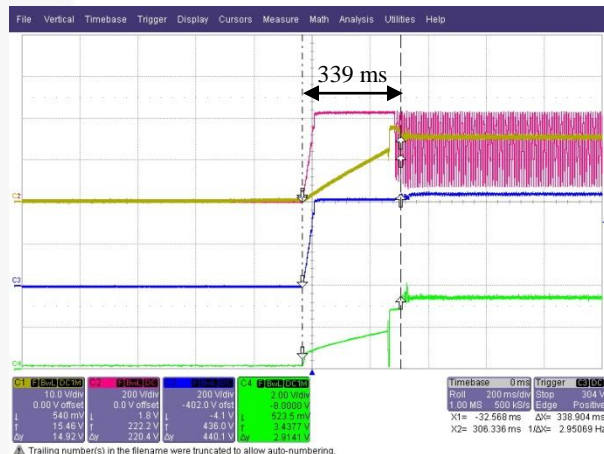


Figure 30. V<sub>IN</sub> = 300V<sub>AC</sub> / 50 Hz

Figure 31 and Figure 32 show the startup and stop performance for the boost converter according to PS-ON switch operation at rated output load. The PFC output voltage is raised rapidly when the PS-ON switch is turned on and V<sub>DD-PFC</sub> drops below UVLO and PFC output starts discharging PFC output capacitors when PS-ON switch was turned off in standby status; CH1: V<sub>DD-PFC</sub> (10 V / div), CH2: V<sub>PS-ON</sub> (2 V / div), CH3: V<sub>OUT\_PFC</sub> (200 V / div), CH4: V<sub>R<sub>RDY</sub></sub> (2 V / div).

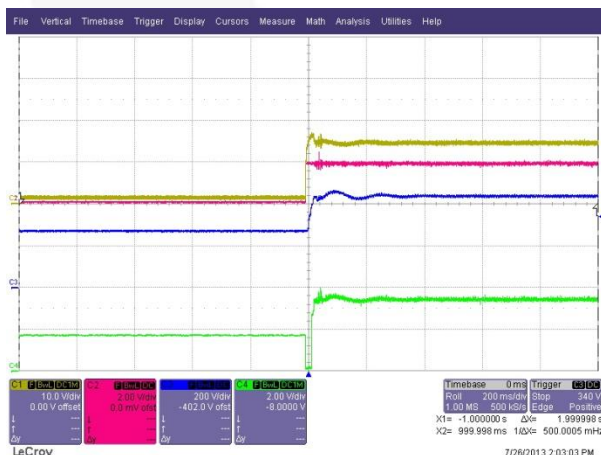


Figure 31. PS-ON, [200 ms/div]



Figure 32. PS-OFF, [500 ms/div]

## 8.7. Startup Performance in LLC Stage

Figure 33 and Figure 34 show the startup performance; including flyback, boost, and LLC converter. The LLC output voltage is raised after about 455 ms and 337 ms, respectively, for input voltage 85 V<sub>AC</sub> and 300 V<sub>AC</sub> condition when the AC input power switch turns on; CH1: V<sub>DD-FLYBACK</sub> (10 V / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>OUT-LLC</sub> (20 V / div), CH4: I<sub>OUT-LLC</sub> (2 A / div), Time Scale: 200 ms / div.



Figure 33. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz

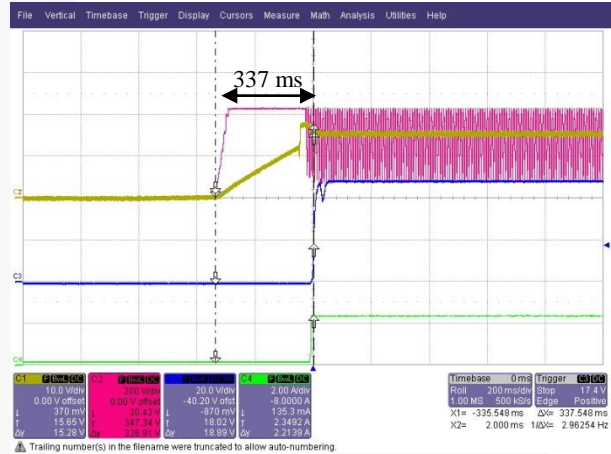


Figure 34. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz

Figure 35 and Figure 36 show the startup and stop performance for the LLC converter according to the PS-ON switch operation at rated output load. The LLC output current is raised up to the rated voltage within 50 ms after the PS-ON switch is turned on and the output current drops to zero quickly when the PS-ON switch is turned off in standby status; CH1: V<sub>DD-LLC</sub> (10 V / div), CH2: V<sub>PS-ON</sub> (2 V / div), CH3: V<sub>OUT-LLC</sub> (20 V / div), CH4: I<sub>OUT-LLC</sub> (2 A / div), Time Scale: 200 ms / div.

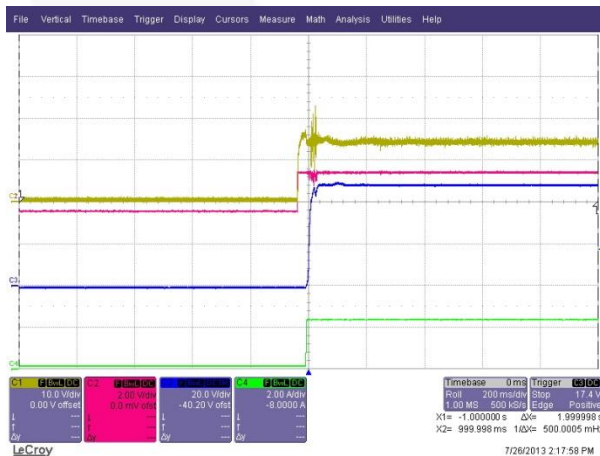


Figure 35. PS-ON

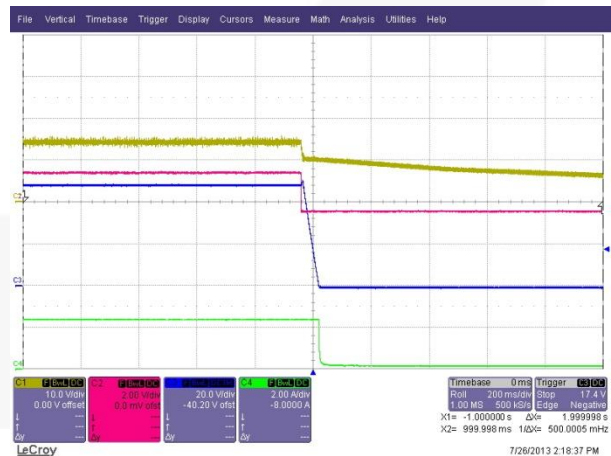


Figure 36. PS-OFF

## 8.8. Key Waveforms for Input and Output

Figure 37 and Figure 38 show AC input and output waveforms at 85 V<sub>AC</sub> and 300 V<sub>AC</sub> line voltage and rated output load condition, respectively; CH1: I<sub>IN</sub> (5 A / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>LED</sub> (50 V / div), CH4: I<sub>LED</sub> (0.5 A / div), Time Scale: 5 ms / div.

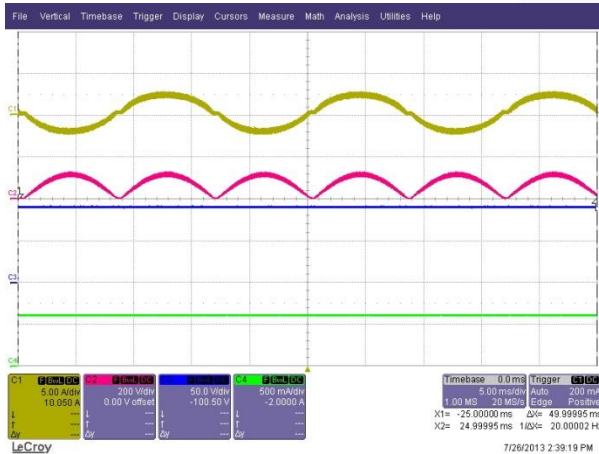


Figure 37. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, 100% Dim

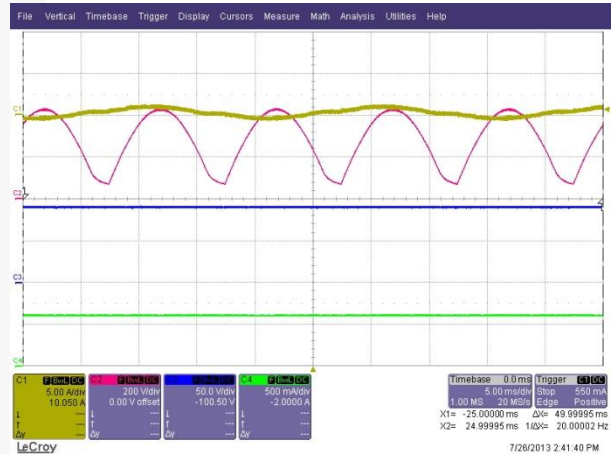


Figure 38. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, 100% Dim

Figure 39 and Figure 40 show AC input and output waveforms at 85 V<sub>AC</sub> and 300 V<sub>AC</sub> line voltage and 50% output load condition, respectively; CH1: V<sub>IN</sub> (2 A / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>OUT</sub> (50 V / div), CH4: I<sub>LED</sub> (0.5 A / div), Time Scale: 5 ms / div.

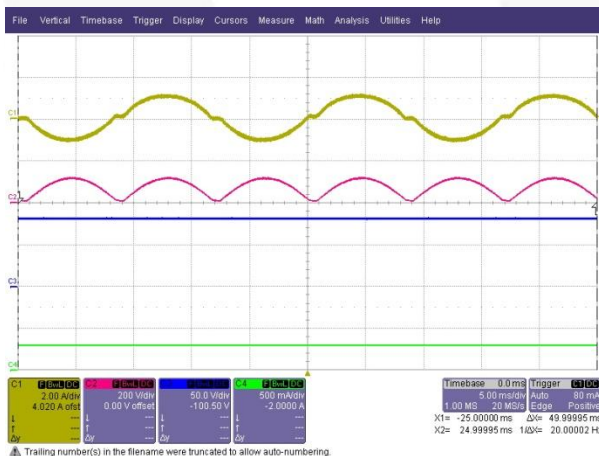


Figure 39. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, 50% Dim



Figure 40. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, 50% Dim

Figure 41 and Figure 42 show AC input and output waveforms at 85 V<sub>AC</sub> and 300 V<sub>AC</sub> line voltage and 10% output load condition, respectively; CH1: V<sub>IN</sub> (1 A / div), CH2: V<sub>IN</sub> (200 V / div), CH3: V<sub>OUT</sub> (50 V / div), CH4: I<sub>LED</sub> (0.5 A / div), Time Scale: 5 ms / div. In case of 300 V<sub>AC</sub>, PFC was operated in Burst Mode, so switching pulse were skipped.

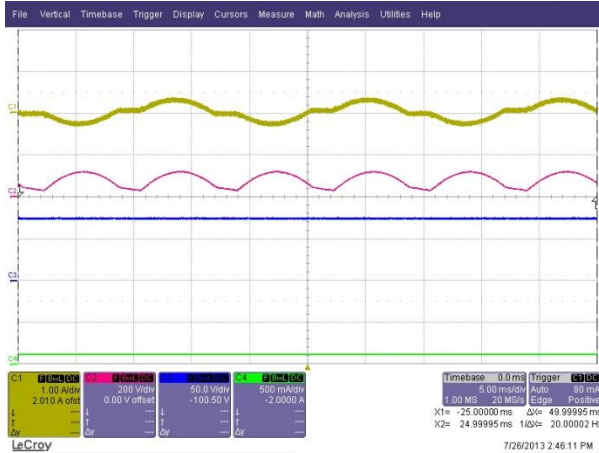


Figure 41. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, 10% Dim



Figure 42. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, 10% Dim

## 8.9. Key Waveforms for Flyback Stage

Figure 43 and Figure 44 show key waveforms of the flyback stage according to the PS-ON switch operation at rated output load condition; CH1: I<sub>DS-ICS802</sub> (0.5 A / div), CH2: V<sub>DS-ICS802</sub> (200 V / div), CH3: V<sub>PS-ON</sub> (2 V / div). Time Scale: 200 ns / div.

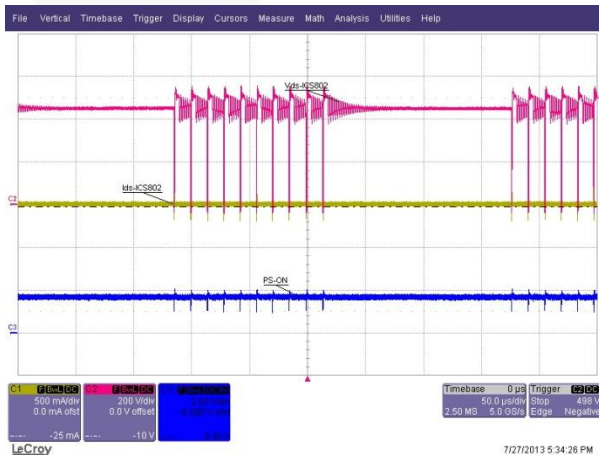


Figure 43. PS-ON

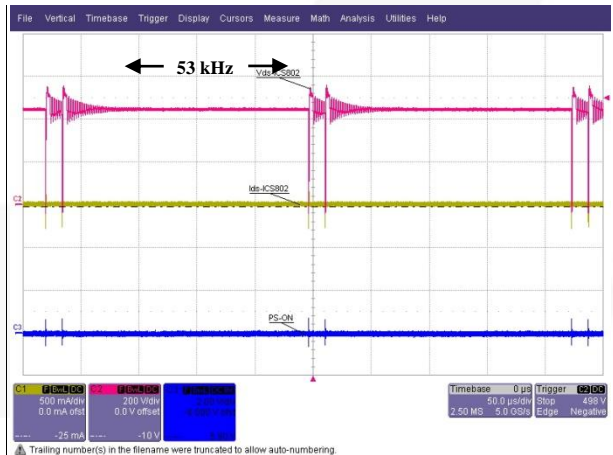


Figure 44. PS-OFF

### 8.10. Key Waveforms for PFC Stage

Figure 45 and Figure 46 show key waveforms of PFC stage at 85 V<sub>AC</sub> line voltage and rated output load condition; CH1: I<sub>DS-QP802</sub> (2 A / div), CH2: V<sub>DS-QP802</sub> (200 V / div), CH3: V<sub>AK-DP802</sub> (200 V / div), CH4: I<sub>AK-DP802</sub> (2 A / div).

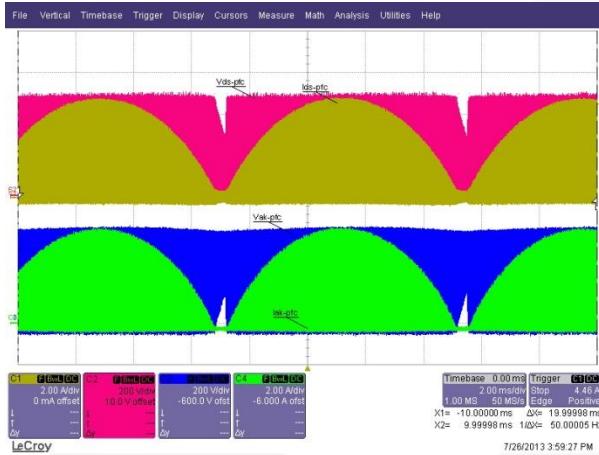


Figure 45. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, [5 ms/div]

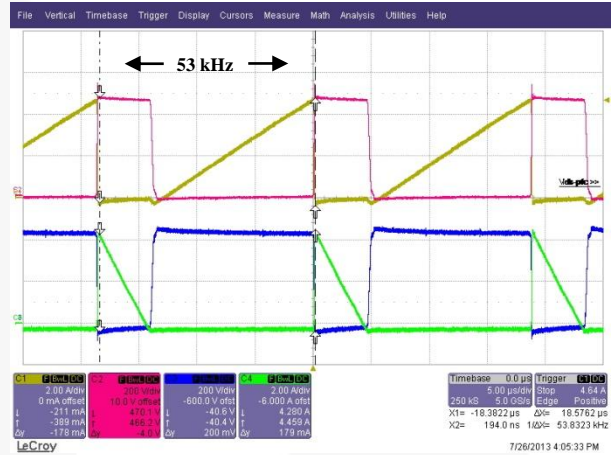


Figure 46. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, [5 μs/div]

Figure 47 and Figure 48 show key waveforms of PFC stage at 85 V<sub>AC</sub> line voltage and no-load condition; CH1: I<sub>DS-QP802</sub> (0.5 A / div), CH2: V<sub>DS-QP802</sub> (200 V / div), CH3: V<sub>AK-DP802</sub> (200 V / div), CH4: I<sub>AK-DP802</sub> (0.5 A / div).

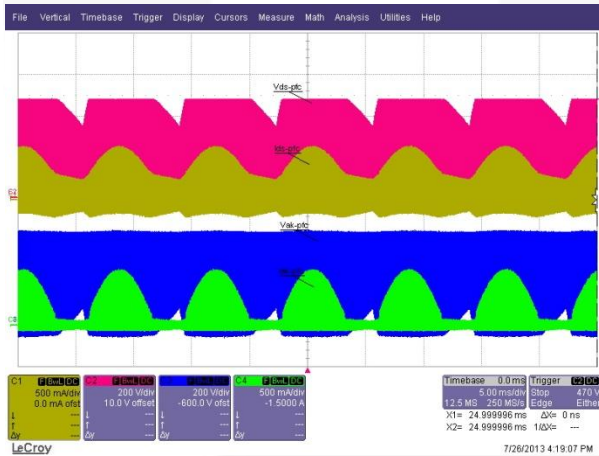


Figure 47. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, [5 ms/div]

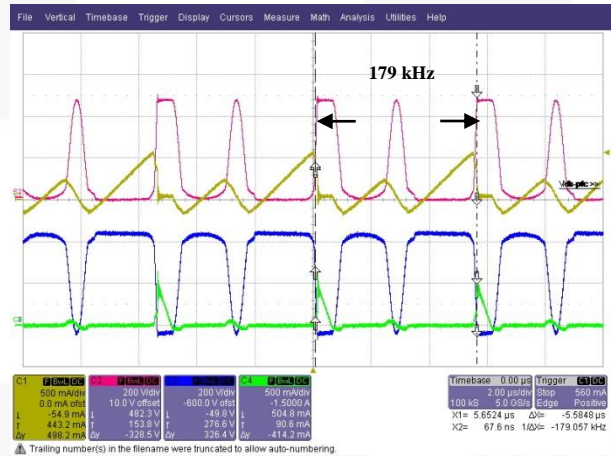


Figure 48. V<sub>IN</sub> = 85 V<sub>AC</sub> / 60 Hz, [2 μs/div]

Figure 49 and Figure 50 show key waveforms of the PFC stage at 300 V<sub>AC</sub> line voltage and rated output load condition; CH1: I<sub>DS\_QP802</sub> (2 A / div), CH2: V<sub>DS\_QP802</sub> (200 V / div), CH3: V<sub>AK\_DP802</sub> (200 V / div), CH4: I<sub>AK\_DP802</sub> (2 A / div).

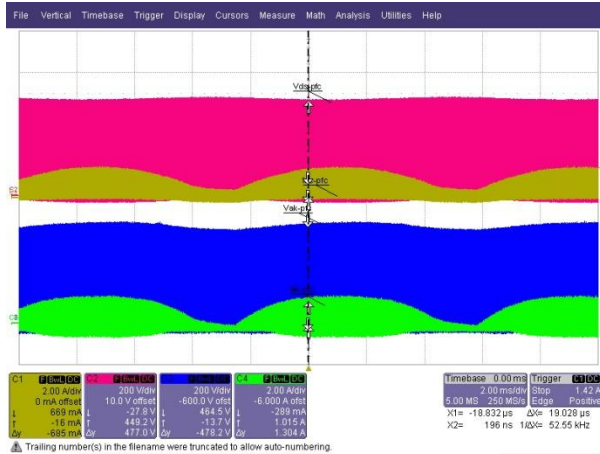


Figure 49. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, [2 ms/div]

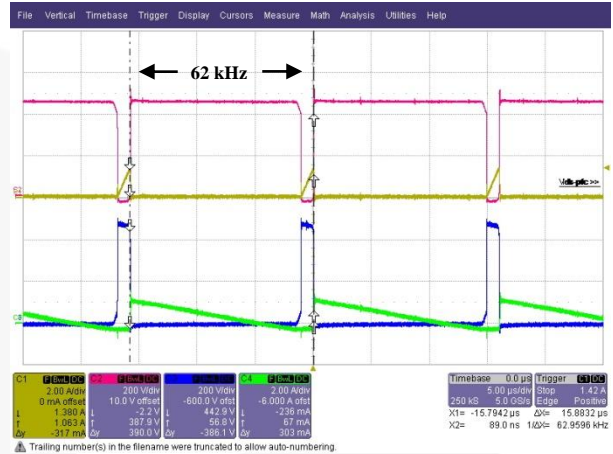


Figure 50. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, [5 μs/div]

Figure 51 and Figure 52 show key waveforms of the PFC stage at 300 V<sub>AC</sub> line voltage and no-load condition; CH1: I<sub>DS\_QP802</sub> (0.5 A / div), CH2: V<sub>DS\_QP802</sub> (200 V / div), CH3: V<sub>AK\_DP802</sub> (200 V / div), CH4: I<sub>AK\_DP802</sub> (0.5 A / div).

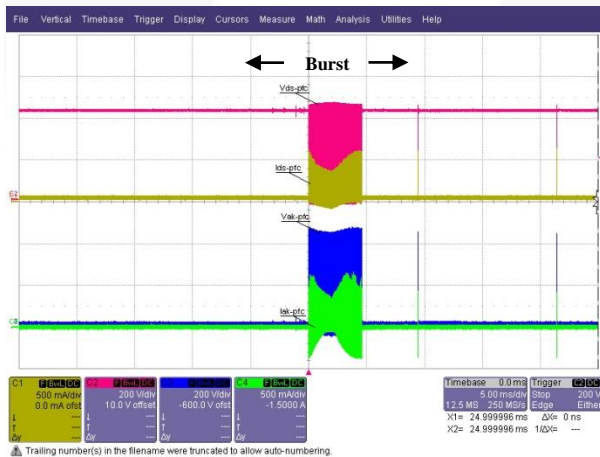


Figure 51. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, [5 ms/div]

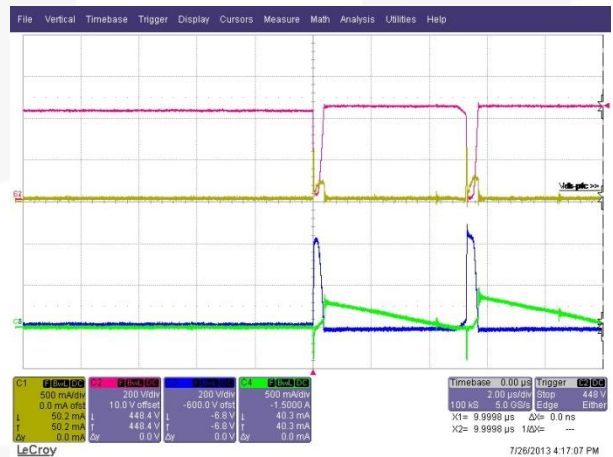


Figure 52. V<sub>IN</sub> = 300 V<sub>AC</sub> / 50 Hz, [2 μs/div]

### 8.11. Key Waveforms for LLC Stage

Figure 53 and Figure 54 show key waveforms in the primary side of the LLC converter at rated output load condition; CH1:  $V_{GATE-QM802}$  (10 V / div), CH2:  $V_{GATE-QM801}$  (10 V / div), CH3:  $V_{Cr-CM816}$  (200 V / div), CH4:  $I_{Lr-TM801}$  (1.0 A / div).

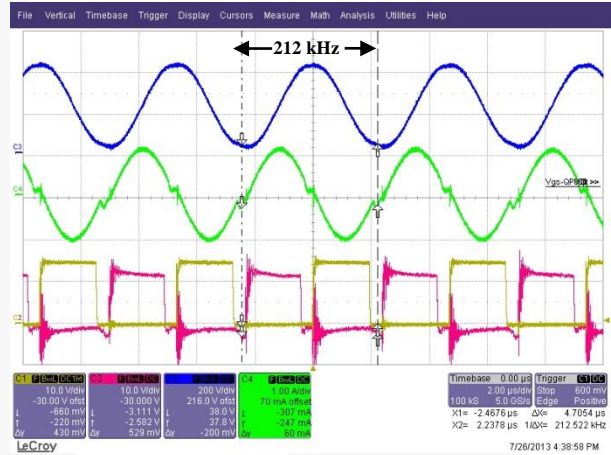
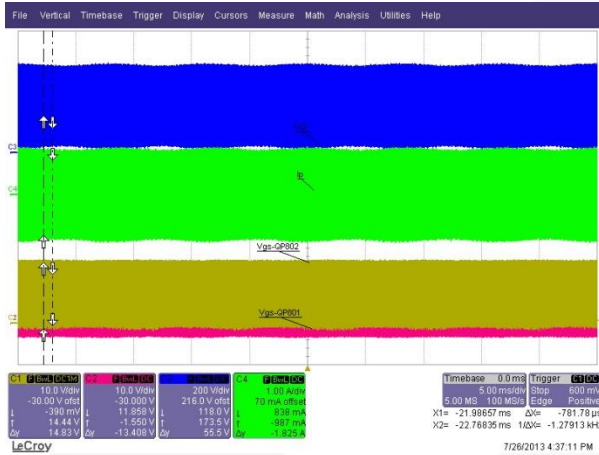


Figure 55 and Figure 56 show key waveforms in the secondary side of the LLC converter at rated output load condition; CH1:  $I_{Secondary}$  (2.0 A / div), CH2:  $V_{AK\_DM802}$  (100 V / div), CH3:  $V_{AK\_DM801}$  (100 V / div).

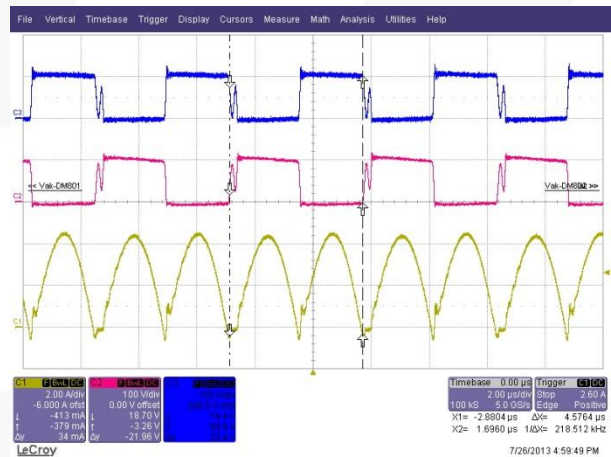
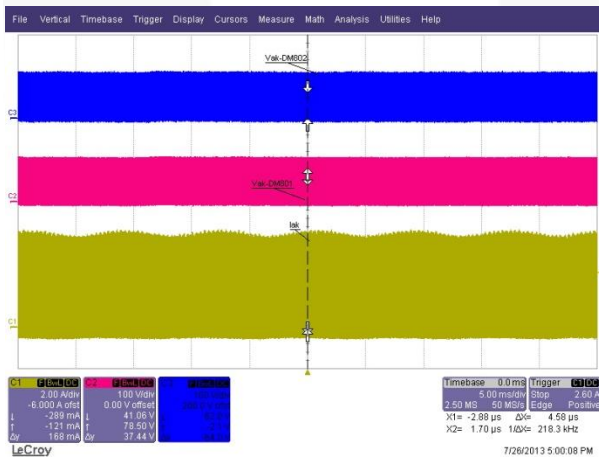


Figure 57 and Figure 58 show key waveforms in the primary side of the LLC converter at no-load condition; CH1:  $V_{GATE\_QM802}$  (10 V / div), CH2:  $V_{GATE\_QM801}$  (10 V / div), CH3:  $V_{Cr\_CM816}$  (200 V / div), CH4:  $I_{Lr\_TM801}$  (1.0 A / div).

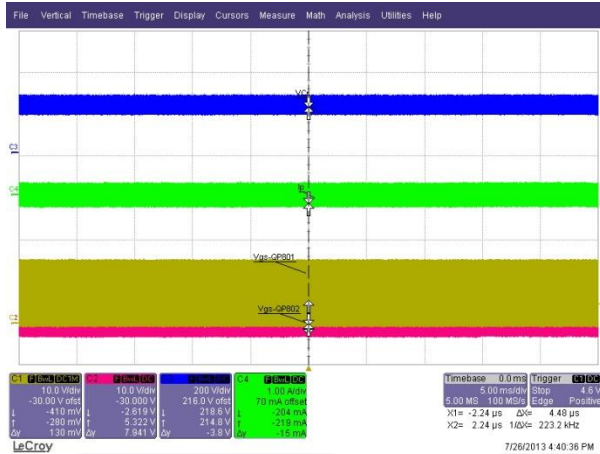


Figure 57. No Load [5 ms/div]

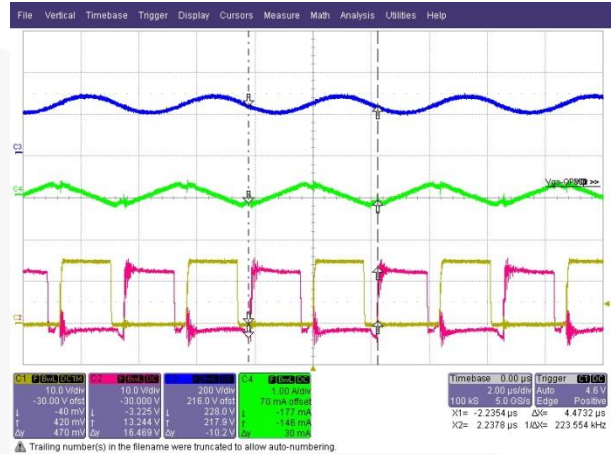


Figure 58. No Load [2 μs/div]

Figure 59 and Figure 60 show key waveforms in the secondary side of the LLC converter at no-load condition; CH1:  $I_{Secondary}$  (0.5 A / div), CH2:  $V_{AK\_DM802}$  (100 V / div), CH3:  $V_{AK\_DM802}$  (100 V / div).

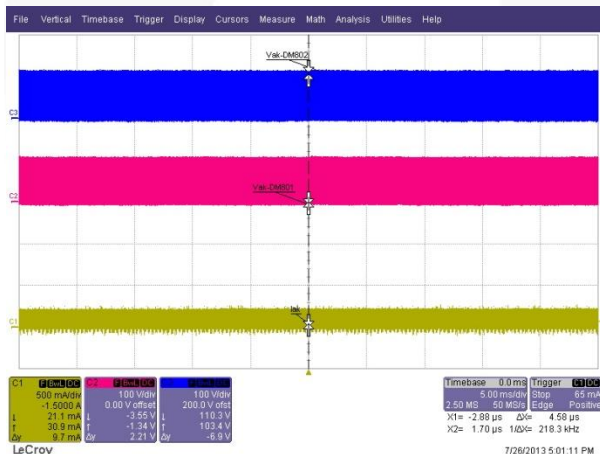


Figure 59. No Load [5 ms/div]

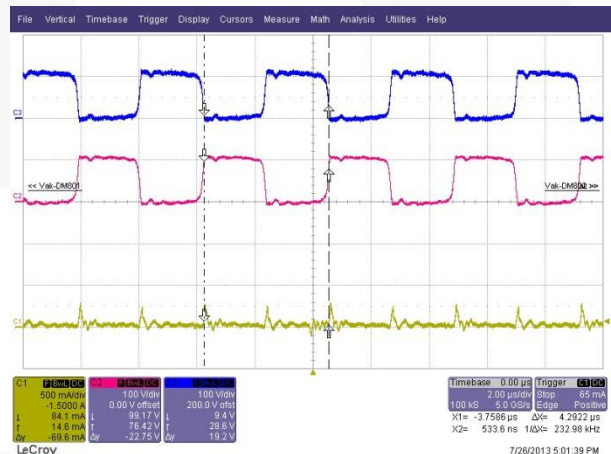


Figure 60. No Load [2 μs/div]



## 8.12. Key Waveforms for Single-Channel Boost Stage

Figure 61 and Figure 62 show key waveforms of a single-channel boost converter at rated output load condition; CH1:  $I_{DS\_QL802}$  (2.0 A / div), CH2:  $V_{DS\_QL802}$  (100 V / div), CH3:  $V_{AK\_DL802}$  (100V / div), CH4:  $I_{AK\_DL802}$  (2.0 A / div).



Figure 61. Rated Load [2 ms/div]

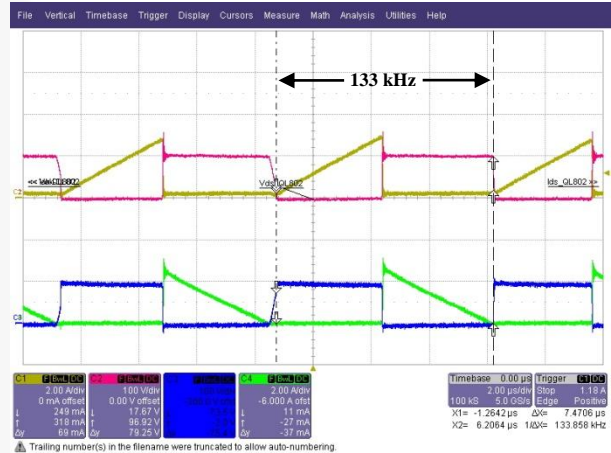


Figure 62. Rated Load [2 us/div]

Figure 63 and Figure 64 show key waveforms of a single-channel boost converter at 10% load condition; CH1:  $I_{DS\_QL802}$  (2.0 A / div), CH2:  $V_{DS\_QL802}$  (100 V / div), CH3:  $V_{AK\_DL802}$  (100 V / div), CH4:  $I_{AK\_DL802}$  (2.0 A / div).



Figure 63. 10% Load [2 ms/div]

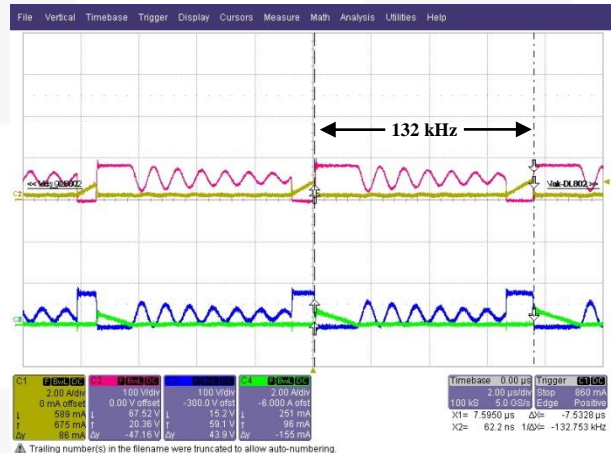


Figure 64. 10% Load [2 us/div]

### 8.13. Dimming Performance

Figure 65 and Figure 66 show key waveforms for analog dimming performance of a single-channel boost converter at 10% ADIM ( $V_{ADIM}$ : 0.12 V) and 100% BDIM; CH1:  $I_{LED}$  (0.2 A / div), CH2:  $V_{GATE-QL802}$  (5.0 V / div), CH3:  $V_{BDIM}$  (5.0 V / div), CH4:  $V_{ADIM}$  (0.5 V / div).



Figure 65. 10% ADIM [2 ms/div]

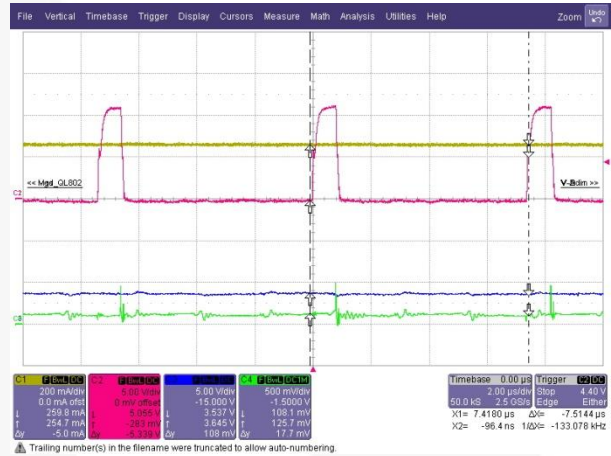


Figure 66. 10% ADIM [2 μs/div]

Figure 67 and Figure 68 show key waveforms for PWM dimming performance of a single-channel boost converter at 100% ADIM ( $V_{ADIM}$ : 1.2 V) and 1% BDIM; CH1:  $I_{LED}$  (0.5 A / div), CH2:  $V_{GATE-QL802}$  (5.0 V / div), CH3:  $V_{BDIM}$  (5.0 V / div), CH4:  $V_{ADIM}$  (0.5 V / div).

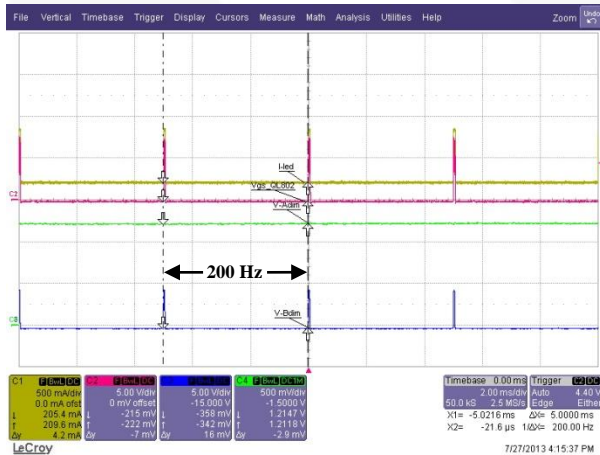


Figure 67. 1% BDIM [2 ms/div]

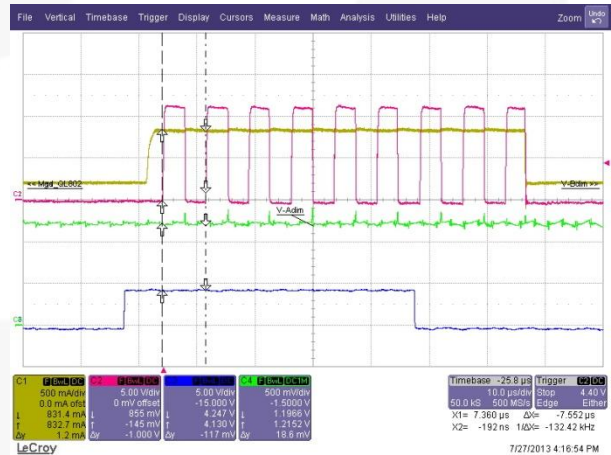
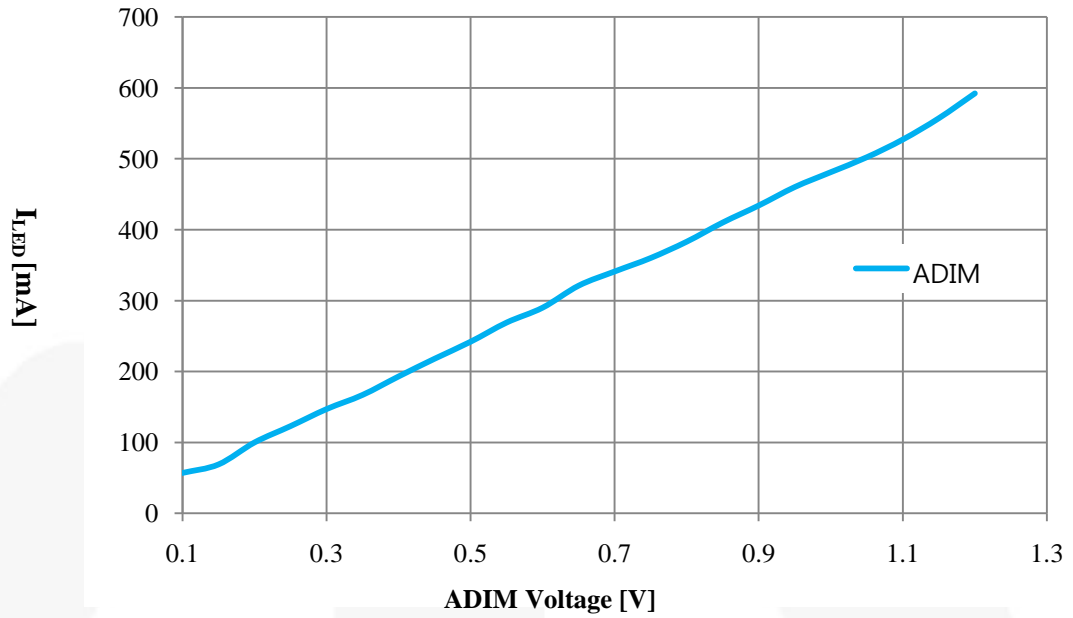
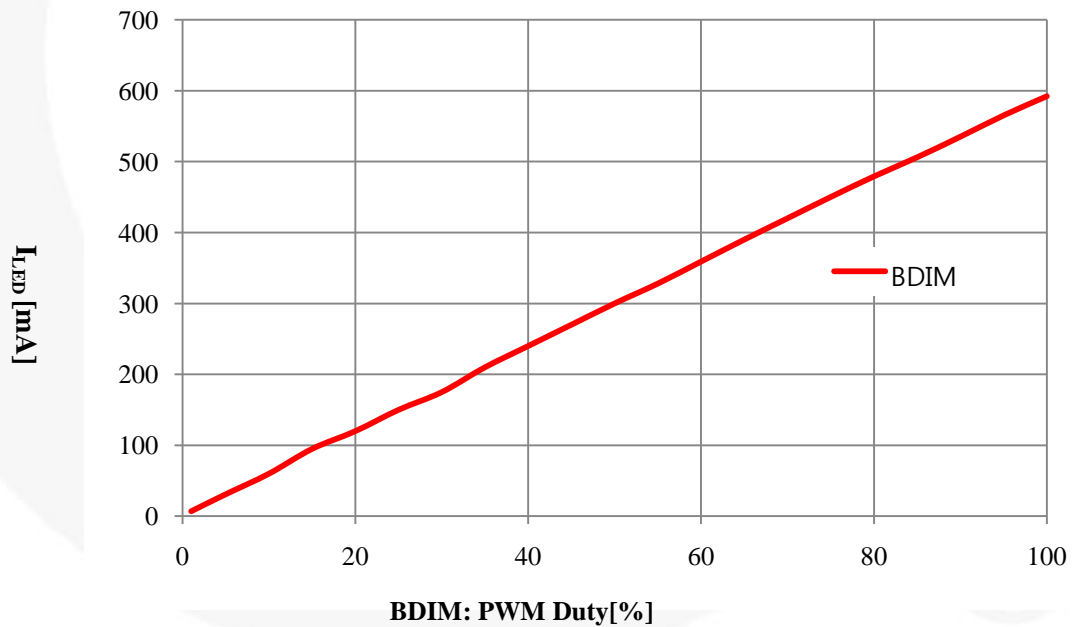


Figure 68. 1% BDIM [10 μs/div]

Figure 69 and Figure 70 show the FAN73402's analog [ADIM] and PWM [BDIM] dimming characteristic curves.



**Figure 69. Analog Dimming Characteristics**



**Figure 70. PWM Characteristics**

### 8.14. LED Short / Open Protection at Multi-Channel Output

Figure 71 and Figure 72 show waveforms for output voltage and current when an LED is shorted and recovered in one of the LED channels [100 V/0.6 A]; CH1:  $I_{LED}$  (0.5 A / div), CH2:  $V_{LED}$  (50 V / div), CH3:  $V_{GATE-QL802}$  (5 V / div), Time Scale: 100 ms / div.

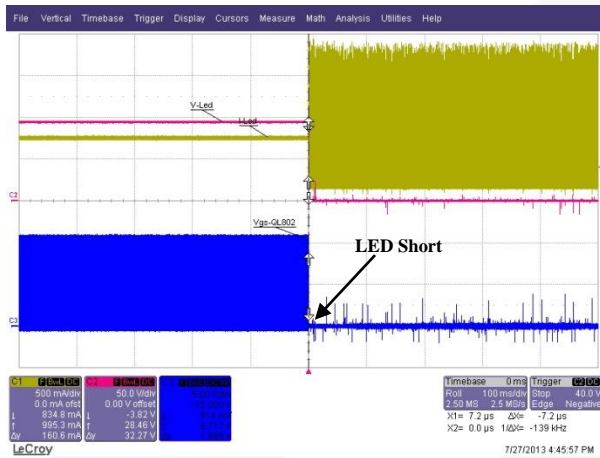


Figure 71. LED Short

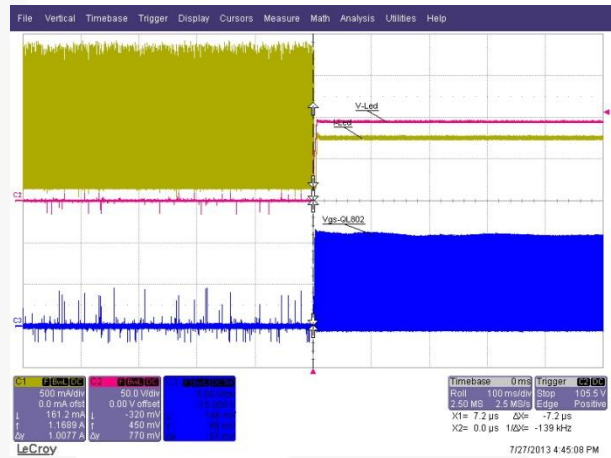


Figure 72. Recover from LED Short

Figure 73 and Figure 74 show waveforms for output voltage and current when an LED is opened and recovered in one of the LED channels [100 V/0.6 A]; CH1:  $I_{LED}$  (0.5 A / div), CH2:  $V_{LED}$  (50 V / div), CH3:  $V_{GATE-QL802}$  (5 V / div), Time Scale: 100 ms / div.



Figure 73. LED Open

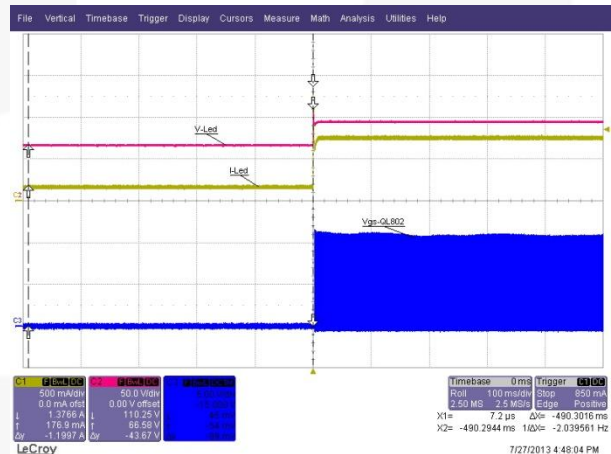


Figure 74. Recover from LED Open

### 8.15. Operating Temperature

Figure 75 shows temperatures measured for the primary and secondary active components in the top side at 85 V<sub>AC</sub> line voltage and rated output load [two LED channels: 100 V/1.2 A].

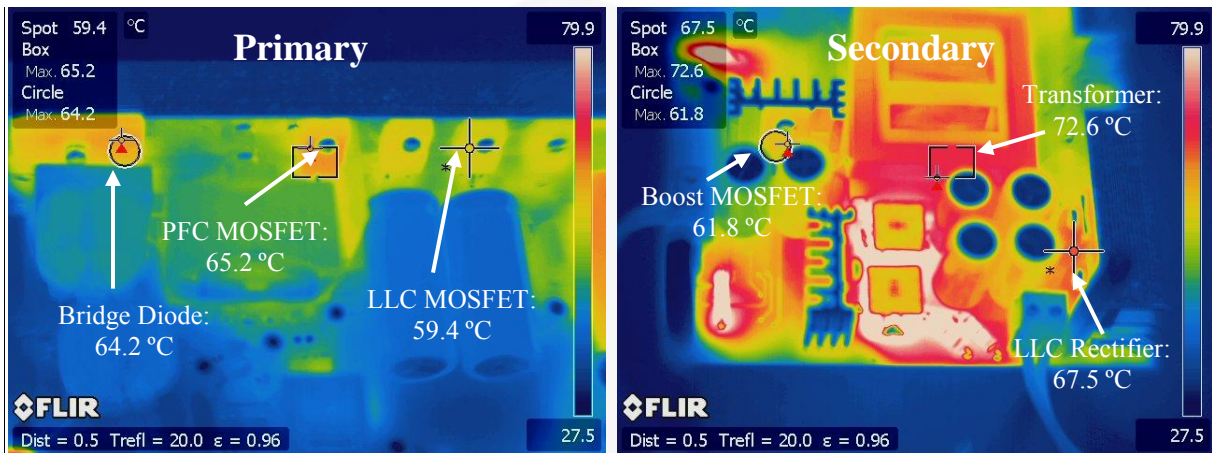


Figure 75. Board Temperature - V<sub>IN</sub>[85 V<sub>AC</sub>]

Figure 76 shows temperatures measured for the primary [top] and secondary [bottom] active components at 300 V<sub>AC</sub> line voltage and rated output load [two LED channels: 100 V/1.2 A].

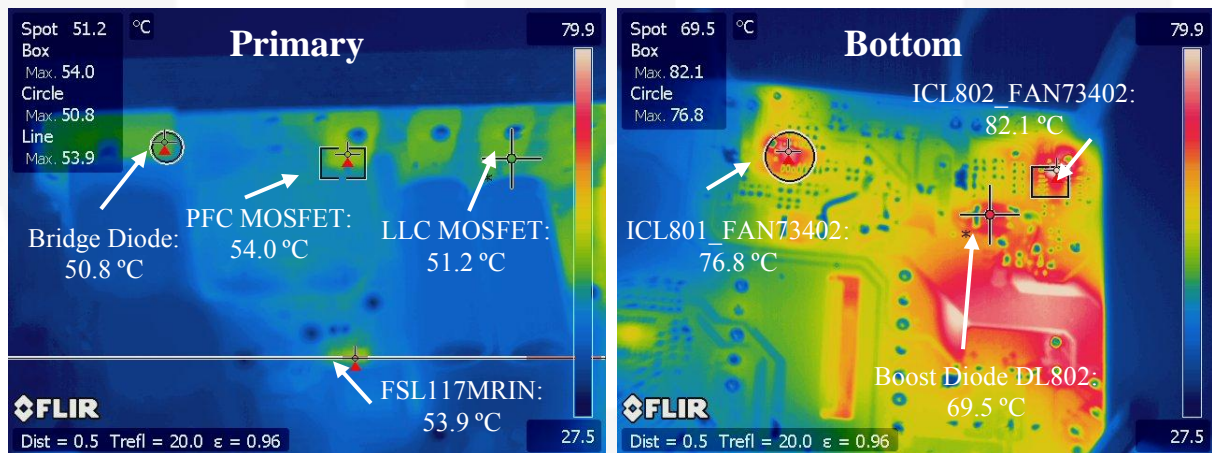


Figure 76. Board Temperature - V<sub>IN</sub>[300 V<sub>AC</sub>]

Note: The FAN73402 temperature can be reduced by changing PCB layout.

## 9. Revision History

| Rev.  | Date       | Description     |
|-------|------------|-----------------|
| 1.0.0 | July. 2013 | Initial Release |
|       |            |                 |
|       |            |                 |
|       |            |                 |

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