

# NCL30073LED2GEVB

## 15 W High Power Factor LED Driver Evaluation Board User's Manual



ON Semiconductor®

[www.onsemi.com](http://www.onsemi.com)

### EVAL BOARD USER'S MANUAL

#### Overview

This manual covers the specification, theory of operation, testing and construction of the NCL30073LED2GEVB evaluation board. The NCL30073 board demonstrates a 15 W high PF flyback LED driver for a typical downlight application.

#### Key Features

The key features of this evaluation board include:

- Low Parts Count
- TRIAC Dimmer compatible
- High Power Factor
- Integrated Fault Protection
  - ◆ Over Temperature on board (a PCB mounted PTC)
  - ◆ Output Over Current
  - ◆ Output Over Voltage

Table 1. SPECIFICATIONS

|                          |                |         |
|--------------------------|----------------|---------|
| Input voltage            | 207 – 253 V ac |         |
| Line Frequency           | 50/60 Hz       |         |
| Power Factor (100% Load) | 0.9            | Min     |
| Output Voltage           | 36 V dc        |         |
| Output Ripple            | 17%            | Pk – Pk |
| Output Current           | 415 mA dc      | ± 5%    |
| Efficiency               | 85.7%          | Typ.    |
| Start Up Time            | < 250 msec     | Typ.    |

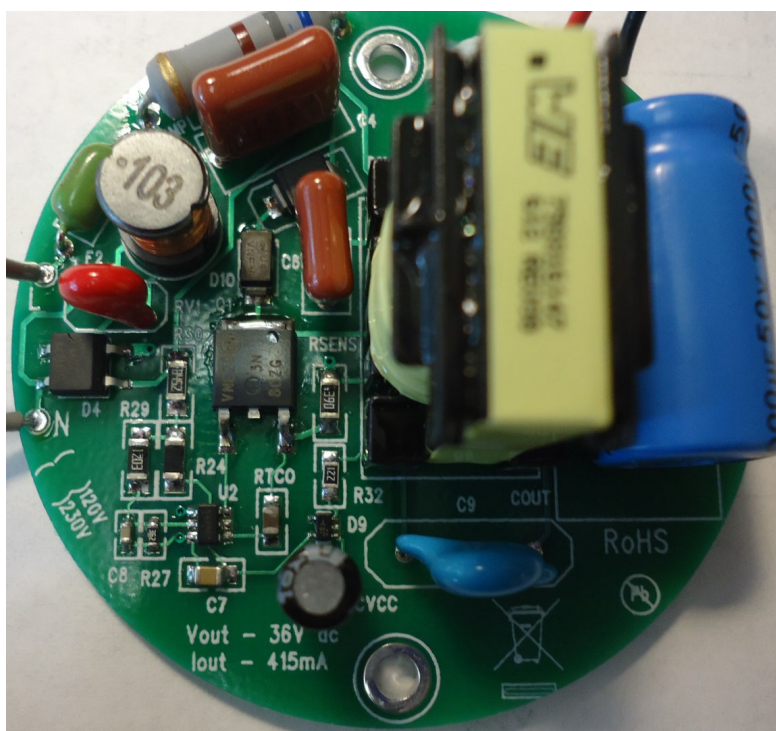


Figure 1. Evaluation Board Photo

## THEORY OF OPERATION

### Power Stage

The power stage is a flyback design. The power stage operates as a fixed frequency DCM power stage. The DCM allows for no forced commutation of the output diode for good EMI performance. The fixed current/fixed frequency

provides for a constant power control over a large portion of the input waveform. The resistor divider of R27 and R29 provides some wave shaping to improve the power factor. The input current waveform is made to be square for maximum TRIAC dimmer compatibility.



Figure 2.

### Output Voltage Sense and Vcc Generation

D9 is rectifies the voltage on the aux winding and stores energy in Cvcc. Cvcc is diode isolated from U2 Vcc to allow for fast start up. C7 will charge much faster than Cvcc and allow for fast starting.

In cases where the output has a lot of ripple current and the LED has high dynamic resistance, the peak output voltage can be much higher than the average output voltage. The inductor winding will charge the Cvcc to the peak of the output voltage which may trigger the OVP sooner than expected so in this case the peak voltage of the LED string is critical.

### Protection

#### Thermal Protection

Rtco is a PTC connected between the CS pin and Rsens. The controller creates an internal signal current from the CS pin. As the resistance of Rtco becomes larger with temperature, the signal level at the CS pin increases causing the current to foldback with temperature.

#### Programmable OVP

The OVP threshold is 25 V on the Vcc pin of U2. This is set by the turns ratio of the flyback transformer. A transformer change is necessary to adjust the OVP threshold. R32 helps to filter the leakage inductance spike to avoid false OVP.

#### Overcurrent Protection

The controller has built in overcurrent limits.

#### Output Current

The output current is set by the value of Rsens. It's possible to adjust the output current by changing Rsens.

#### TRIAC Dimming Compatibility

The EMI filter components are selected to provide optimum damping of the EMI filter to eliminate ringback of the input current which will lead to loss of hold current in the dimmer. The square nature of the input current makes the best case for TRIAC holding current over the line cycle while still maintaining power factor above 0.9.

# NCL30073LED2GEVB

## SCHEMATIC

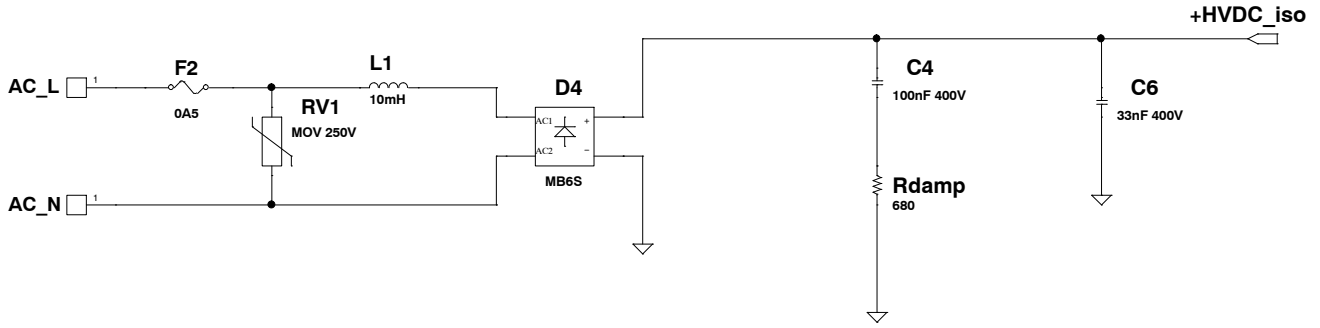


Figure 3. Input Circuit

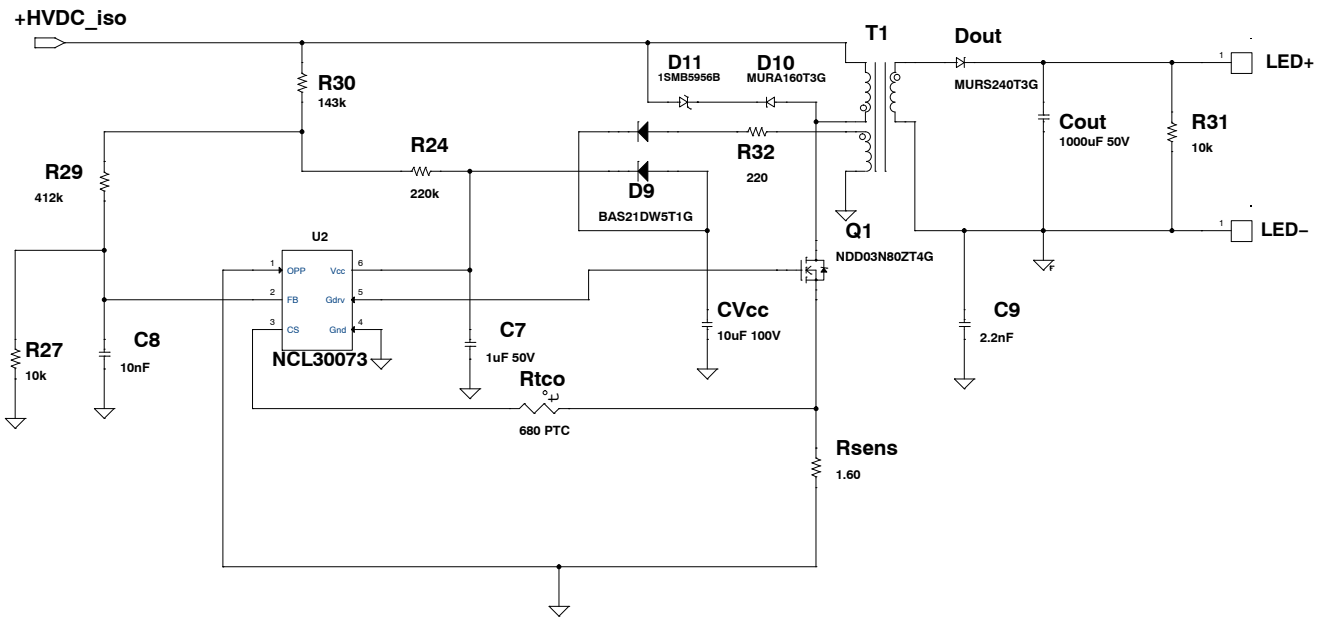


Figure 4. Main Circuit

# NCL30073LED2GEVB

## BILL OF MATERIAL

**Table 2. BILL OF MATERIAL**

| Reference | Qty | Part              | Distributor      | Distributor Part Number | Manufacturer     | Manufacturer Part Number | Substitution Allowed |
|-----------|-----|-------------------|------------------|-------------------------|------------------|--------------------------|----------------------|
| CVcc      | 1   | 10 $\mu$ F 100 V  | Rubycon          | 100YXJ10M5X11           | Digikey          | 1189-2150-ND             | Yes                  |
| Cout      | 1   | 1000 $\mu$ F 50 V | Vishay           | MAL214251102E3          | Digikey          | 4603PHBK-ND              | Yes                  |
| C4        | 1   | 100 nF 400 V      | Faratronic       | C252G104-40****+++      | Faratronic       | C252G104-40****+++       | Yes                  |
| C6        | 1   | 33 nF 400 V       | Faratronic       | C252G333-20****+++      | Faratronic       | C252G333-20****+++       | Yes                  |
| C7        | 1   | 1 $\mu$ F 50 V    | Yageo            | CC0805KKX7R9BB105       | Digikey          | 311-1886-1-ND            | Yes                  |
| C8        | 1   | 10 nF             | Yageo            | CC0603KRX7R9BB103       | Digikey          | 311-1085-1-ND            | Yes                  |
| C9        | 1   | 2.2 nF            | Murate           | DE1E3KX222MN4AL01       | Digikey          | 490-7889-1-ND            | Yes                  |
| Dout      | 1   | MURS240T3G        | ON Semiconductor | MURS240T3G              | ON Semiconductor | MURS240T3G               | No                   |
| D4        | 1   | MB6S              | MCC              | MB6S                    | Digikey          | MB6S-TPMSCT-ND           | Yes                  |
| D9        | 1   | BAS21DW5T1G       | ON Semiconductor | BAS21DW5T1G             | ON Semiconductor | BAS21DW5T1G              | No                   |
| D10       | 1   | MURA160T3G        | ON Semiconductor | MURA160T3G              | ON Semiconductor | MURA160T3G               | No                   |
| D11       | 1   | 1SMB5956B         | ON Semiconductor | MMSZ18T1                | ON Semiconductor | 1SMB5956B                | No                   |
| F2        | 1   | 0A5               | Littelfuse       | 0263.500WRT1L           | Digikey          | F1999CT-ND               | Yes                  |
| L1        | 1   | 10 mH             | Würth            | 744772103               | Digikey          | 732-3791-ND              | Yes                  |
| Q1        | 1   | NDD03N80ZT4G      | ON Semiconductor | NDD03N80ZT4G            | ON Semiconductor | NDD03N80ZT4G             | No                   |
| RV1       | 1   | MOV 250V          | Littelfuse       | V390ZA05P               | Digikey          | F3361-ND                 | Yes                  |
| Rdamp     | 1   | 680               | Yageo            | RSF200JB-73-680R        | Digikey          | 680W-2-ND                | Yes                  |
| Rsens     | 1   | 1.6               | Yageo            | RC1206FR-071R6L         | Digikey          | 311-1.60FRCT-ND          | Yes                  |
| Rtco      | 1   | 680 PTC           | Epcos            | B59721A90A62            | Digikey          | 495-4312-1-ND            | Yes                  |
| R24       | 1   | 220k              | Yageo            | RC1206FR-07220KL        | Digikey          | 311-220KFRCT-ND          | Yes                  |
| R27       | 1   | 10k               | Yageo            | RC0603FR-0710k0L        | Digikey          | 311-10.0KHRCT-ND         | Yes                  |
| R29       | 1   | 412k              | Yageo            | RC1206FR-07412KL        | Digikey          | 311-412KFRCT-ND          | Yes                  |
| R30       | 1   | 143k              | Yageo            | RC1206FR-07143KL        | Digikey          | 311-143KFRCT-ND          | Yes                  |
| R31       | 1   | 10k               | Yageo            | RC1206FR-0710KL         | Digikey          | 311-10.0KFRTR-ND         | Yes                  |
| R32       | 1   | 220               | Yageo            | RC0805FR-07220RL        | Digikey          | 311-220CRCT-ND           | Yes                  |
| T1        | 1   | XFRM_LINEAR       | Würth            | 7503161467              | Würth            | 750316147                | Yes                  |
| U2        | 1   | NCL30073          | ON Semiconductor | NCL30073                | ON Semiconductor | NCL30073                 | No                   |

NOTE: All components to comply with RoHS 2002/95/EC

# NCL30073LED2GEVB

## GERBER VIEWS

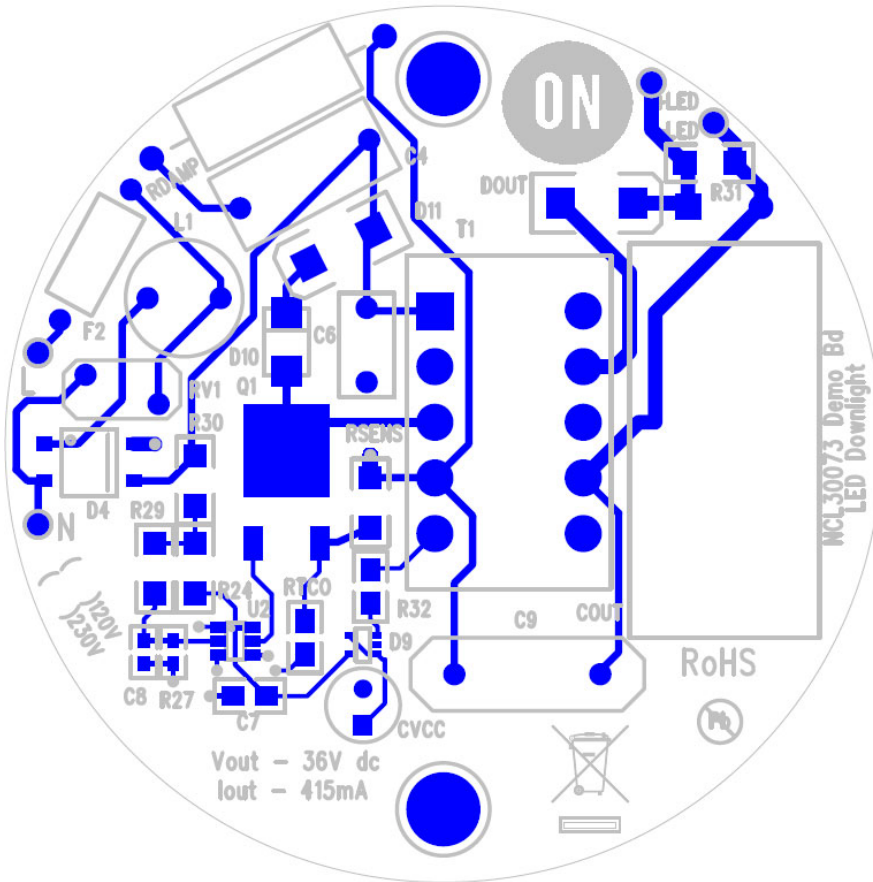


Figure 5. Top Side PCB

## NCL30073LED2GEVB

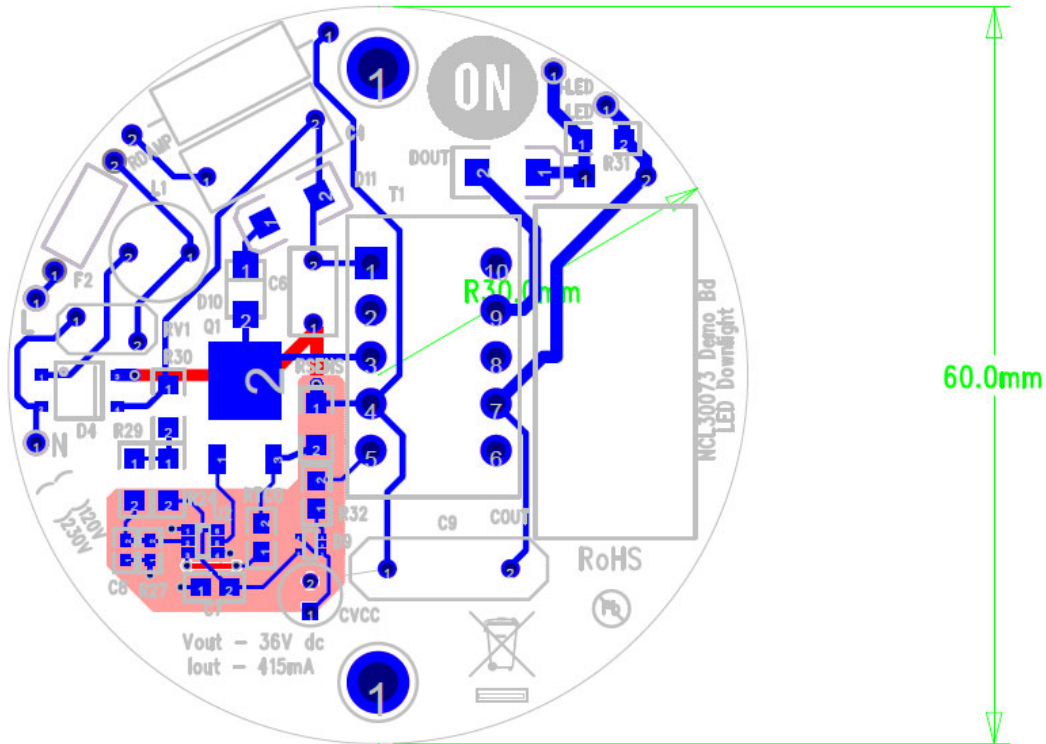


Figure 6. PCB Outline

### Circuit Board Fabrication Notes

1. Fabricate per IPC-6011 and IPC6012. Inspect to IPA-A-600 Class 2 or updated standard.
2. Printed Circuit Board is defined by files listed in fileset.
3. Modification to copper within the PCB outline is not allowed without permission, except where noted otherwise. The manufacturer may make adjustments to compensate for manufacturing process, but the final PCB is required to reflect the associated gerber file design  $\pm 0.001$  in. for etched features within the PCB outline.
4. Material in accordance with IPC-4101/21, FR4, Tg 125°C min.
5. Layer to layer registration shall not exceed  $\pm 0.004$  in.
6. External finished copper conductor thickness shall be 0.0026 in. min. (ie 2oz)
7. Copper plating thickness for through holes shall be 0.0013 in. min. (ie 1oz)
8. All holes sizes are finished hole size.
9. Finished PCB thickness 0.062 in.
10. All un-dimensioned holes to be drilled using the NC drill data.
11. Size tolerance of plated holes:  $\pm 0.003$  in. : non-plated holes  $\pm 0.002$  in.
12. All holes shall be  $\pm 0.003$  in. of their true position U.D.S.
13. Construction to be SMOBC, using liquid photo image (LPI) solder mask in accordance with IPC-SM-B40C, Type B, Class 2, and be green in color.
14. Solder mask mis-registration  $\pm 0.004$  in. max.
15. Silkscreen shall be permanent non-conductive white ink.
16. The fabrication process shall be UL approved and the PCB shall have a flammability rating of UL94V0 to be marked on the solder side in silkscreen with date, manufactures approved logo, and type designation.
17. Warp and twist of the PCB shall not exceed 0.0075 in. per in.
18. 100% electrical verification required.
19. Surface finish: electroless nickel immersion gold (ENIG)
20. RoHS 2002/95/EC compliance required.

# NCL30073LED2GEVB

## ECA PICTURES

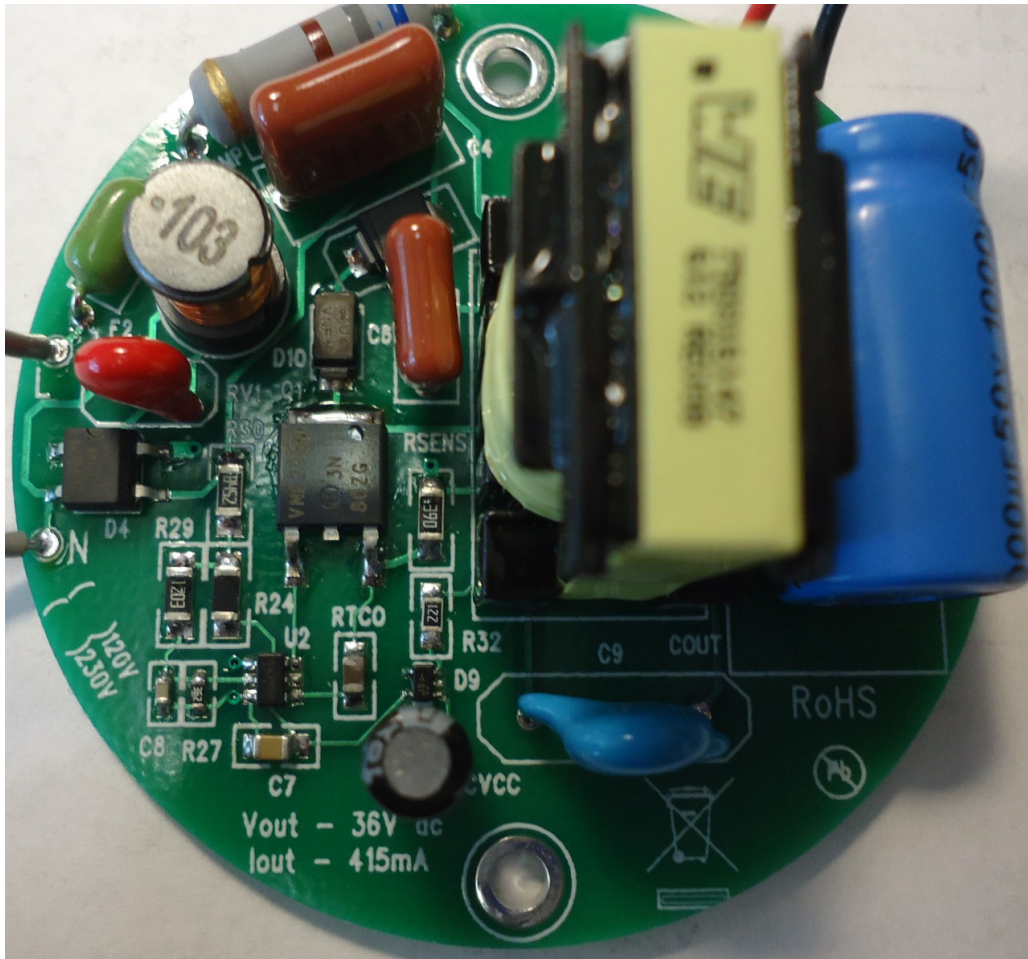


Figure 7. Top View

# NCL30073LED2GEVB

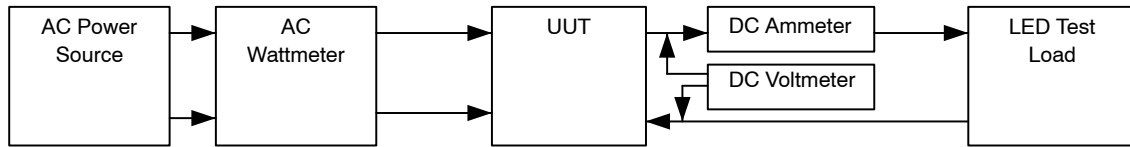
## TEST PROCEDURE

### Equipment Needed

- AC Source – 180 to 270 V ac 50/60 Hz Minimum 100 W capability
- AC Wattmeter – 100 W Minimum, True RMS Input Voltage, Current, Power Factor, and THD 0.2% accuracy or better
- DC Voltmeter – 300 V dc minimum 0.1% accuracy or better
- DC Ammeter – 1 A dc minimum 0.1% accuracy or better
- LED Load – 30 V – 36 V @ 415 mA

### Test Connections

1. Connect the LED Load to the red(+) and black(-) leads through the ammeter shown in Figure 10.  
**Caution: Observe the correct polarity or the load may be damaged.**
2. Connect the AC power to the input of the AC wattmeter shown in Figure 8. Connect the white leads to the output of the AC wattmeter
3. Connect the DC voltmeter as shown in Figure 8.



Note: Unless otherwise specified, all voltage measurements are taken at the terminals of the UUT.

Figure 8. Test Set Up

### Functional Test Procedure

1. Set the LED Load for 36 V output.
2. Set the input power to 230 V 50 Hz.

**Caution: Do not touch the ECA once it is energized because there are hazardous voltages present.**

### Regulation

230 V / Max Load

Table 3.

|       | Output Current | Output Power | Power Factor | THD |
|-------|----------------|--------------|--------------|-----|
| 207 V |                |              |              |     |
| 230 V |                |              |              |     |
| 253 V |                |              |              |     |

$$\text{Efficiency} = \frac{V_{\text{out}} \times I_{\text{out}}}{P_{\text{in}}} \times 100\%$$



# NCL30073LED2GEVB

## TEST DATA

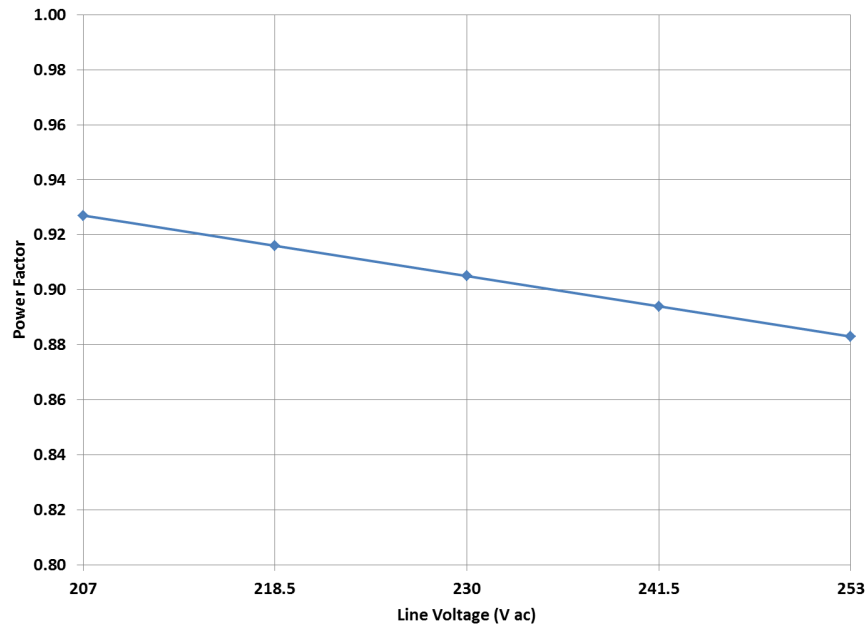


Figure 9. Power Factor Over Line

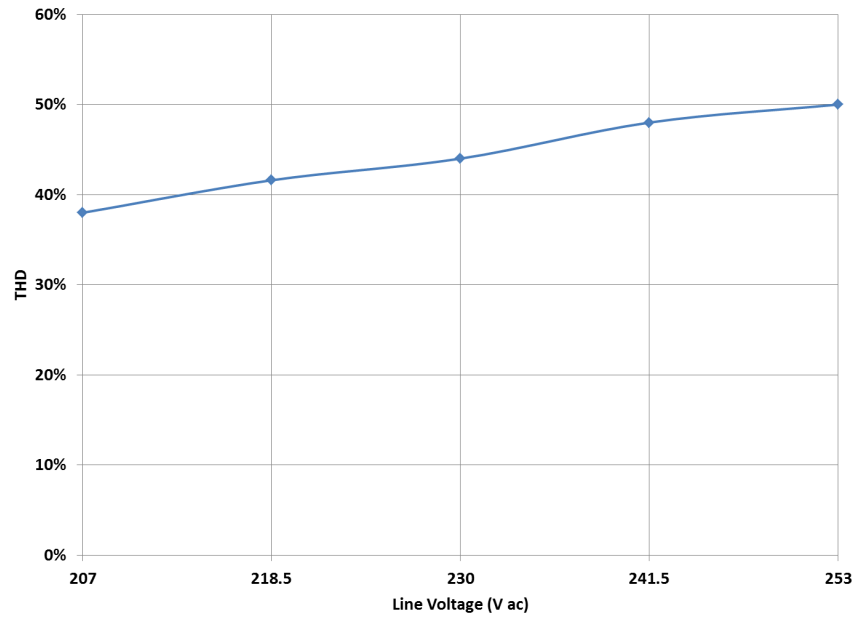


Figure 10. THD Over Line

# NCL30073LED2GEVB

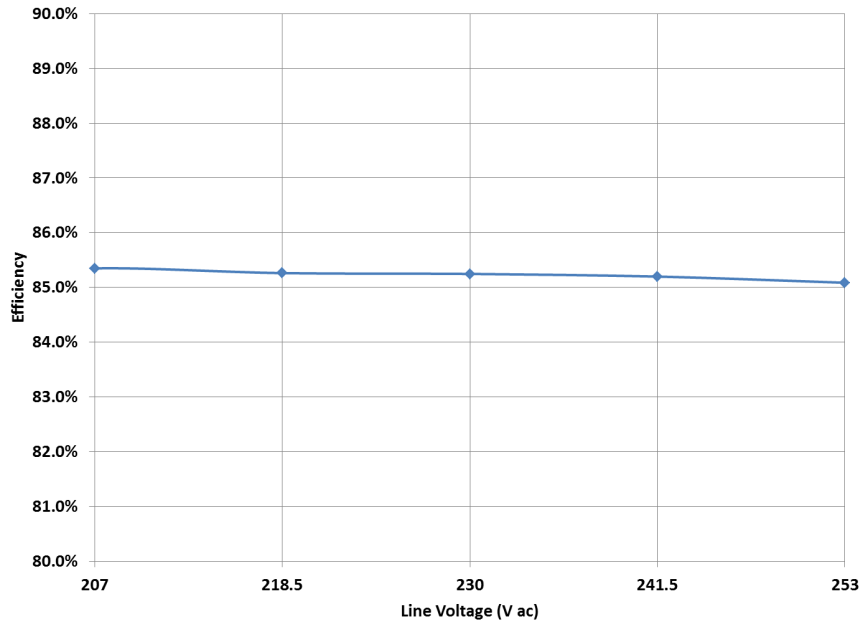


Figure 11. Efficiency

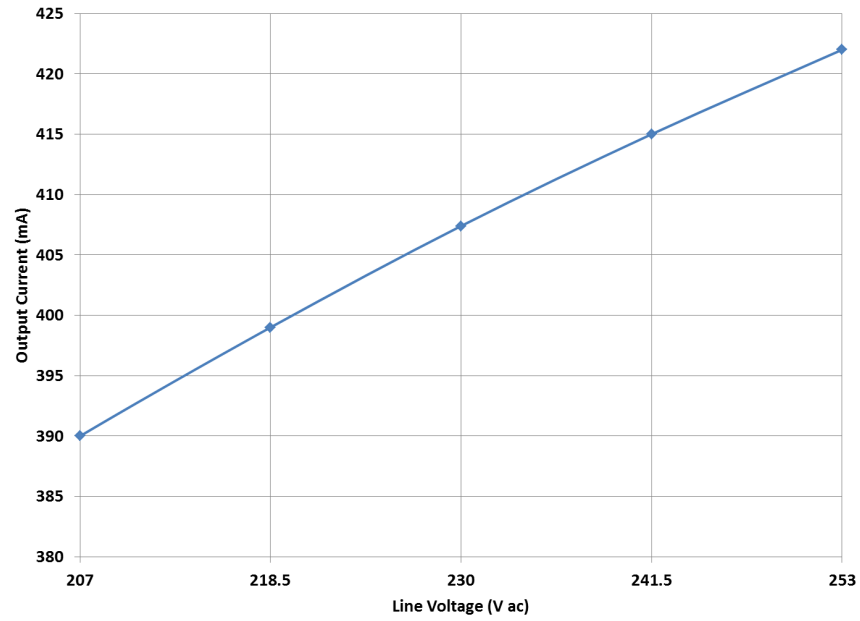


Figure 12. Regulation Over Line

# NCL30073LED2GEVB

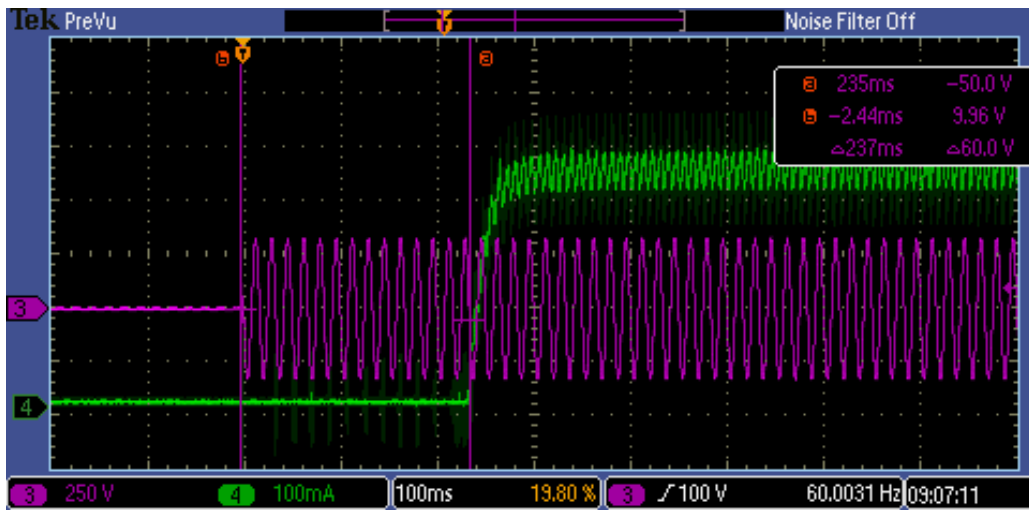


Figure 13. Start Up with AC Applied 230 V

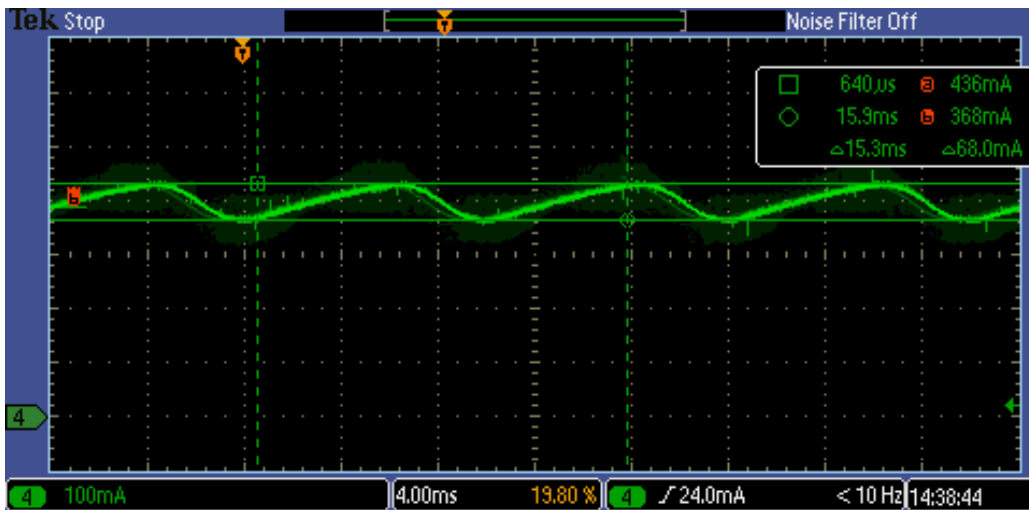


Figure 14. Output Ripple 17% Pk - Pk

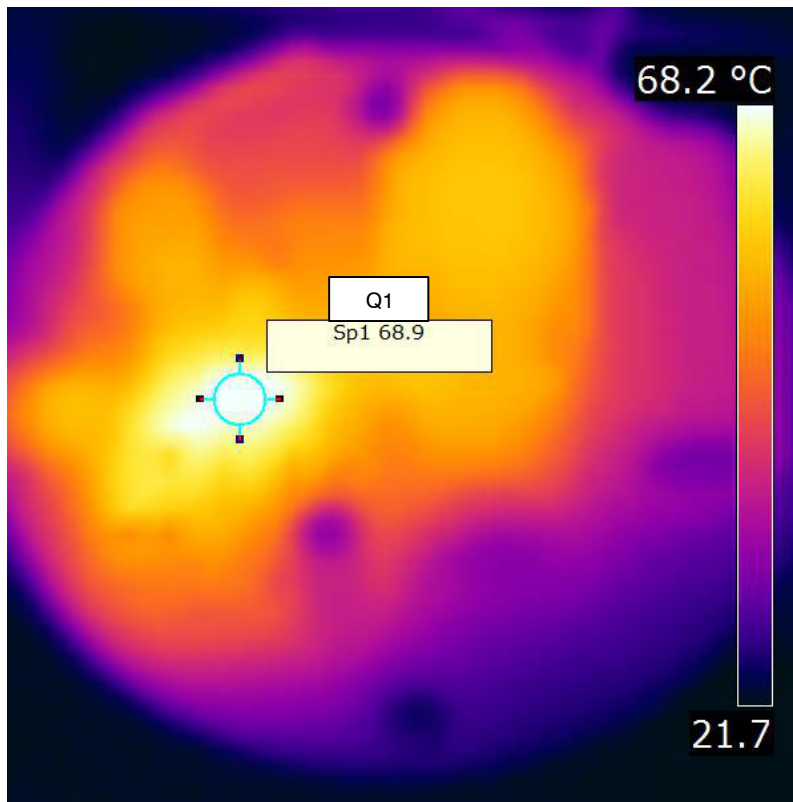


Figure 15.

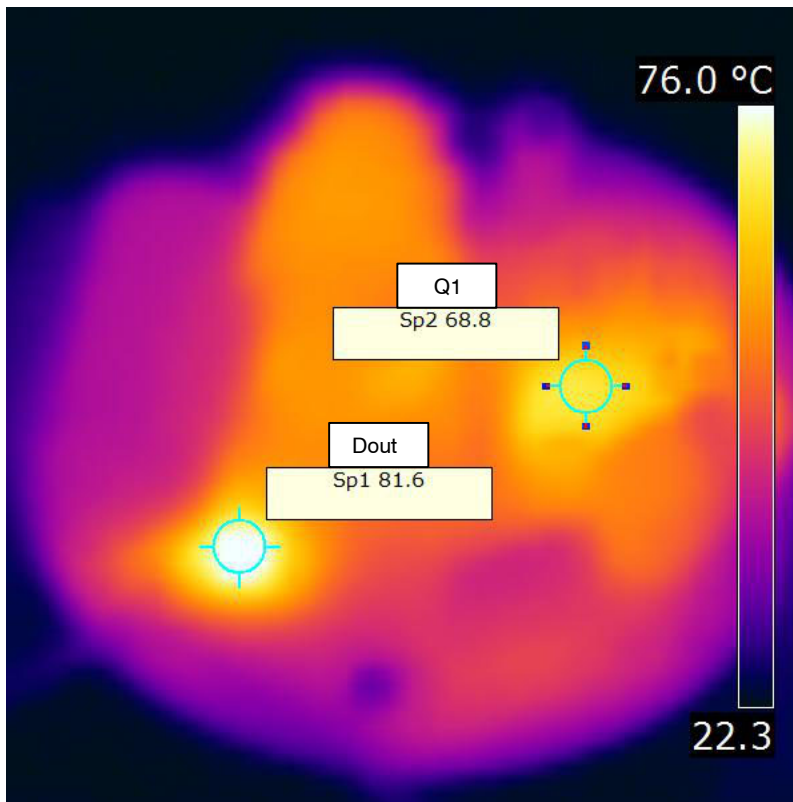


Figure 16. Thermal Image SMT Side

**onsemi**, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

The evaluation board/kit (research and development board/kit) (hereinafter the "board") is not a finished product and is not available for sale to consumers. The board is only intended for research, development, demonstration and evaluation purposes and will only be used in laboratory/development areas by persons with an engineering/technical training and familiar with the risks associated with handling electrical/mechanical components, systems and subsystems. This person assumes full responsibility/liability for proper and safe handling. Any other use, resale or redistribution for any other purpose is strictly prohibited.

**THE BOARD IS PROVIDED BY ONSEMI TO YOU "AS IS" AND WITHOUT ANY REPRESENTATIONS OR WARRANTIES WHATSOEVER. WITHOUT LIMITING THE FOREGOING, ONSEMI (AND ITS LICENSORS/SUPPLIERS) HEREBY DISCLAIMS ANY AND ALL REPRESENTATIONS AND WARRANTIES IN RELATION TO THE BOARD, ANY MODIFICATIONS, OR THIS AGREEMENT, WHETHER EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY AND ALL REPRESENTATIONS AND WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, NON-INFRINGEMENT, AND THOSE ARISING FROM A COURSE OF DEALING, TRADE USAGE, TRADE CUSTOM OR TRADE PRACTICE.**

**onsemi** reserves the right to make changes without further notice to any board.

You are responsible for determining whether the board will be suitable for your intended use or application or will achieve your intended results. Prior to using or distributing any systems that have been evaluated, designed or tested using the board, you agree to test and validate your design to confirm the functionality for your application. Any technical, applications or design information or advice, quality characterization, reliability data or other services provided by **onsemi** shall not constitute any representation or warranty by **onsemi**, and no additional obligations or liabilities shall arise from **onsemi** having provided such information or services.

**onsemi** products including the boards are not designed, intended, or authorized for use in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body. You agree to indemnify, defend and hold harmless **onsemi**, its directors, officers, employees, representatives, agents, subsidiaries, affiliates, distributors, and assigns, against any and all liabilities, losses, costs, damages, judgments, and expenses, arising out of any claim, demand, investigation, lawsuit, regulatory action or cause of action arising out of or associated with any unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of any products and/or the board.

This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and may not meet the technical requirements of these or other related directives.

FCC WARNING – This evaluation board/kit is intended for use for engineering development, demonstration, or evaluation purposes only and is not considered by **onsemi** to be a finished end product fit for general consumer use. It may generate, use, or radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment may cause interference with radio communications, in which case the user shall be responsible, at its expense, to take whatever measures may be required to correct this interference.

**onsemi** does not convey any license under its patent rights nor the rights of others.

LIMITATIONS OF LIABILITY: **onsemi** shall not be liable for any special, consequential, incidental, indirect or punitive damages, including, but not limited to the costs of requalification, delay, loss of profits or goodwill, arising out of or in connection with the board, even if **onsemi** is advised of the possibility of such damages. In no event shall **onsemi**'s aggregate liability from any obligation arising out of or in connection with the board, under any theory of liability, exceed the purchase price paid for the board, if any.

The board is provided to you subject to the license and other terms per **onsemi**'s standard terms and conditions of sale. For more information and documentation, please visit [www.onsemi.com](http://www.onsemi.com).

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Email Requests to: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**onsemi Website:** [www.onsemi.com](http://www.onsemi.com)

### TECHNICAL SUPPORT

**North American Technical Support:**

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

**Europe, Middle East and Africa Technical Support:**

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative