

# NCL30073LED3GEVB

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



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### EVAL BOARD USER'S MANUAL

#### Overview

This manual covers the specification, theory of operation, testing and construction of the NCL30073LED3GEVB evaluation board. The NCL30073 board demonstrates a 15 W high PF buck boost 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            | 108 – 132 V ac |         |
| Line Frequency           | 60 Hz          |         |
| Power Factor (100% Load) | 0.9            | Min     |
| Output Voltage           | 72 V dc        |         |
| Output Ripple            | 75%            | Pk – Pk |
| Output Current           | 200 mA dc      | ± 5%    |
| Efficiency               | 88.5%          | Typ.    |
| Start Up Time            | < 200 msec     | Typ.    |

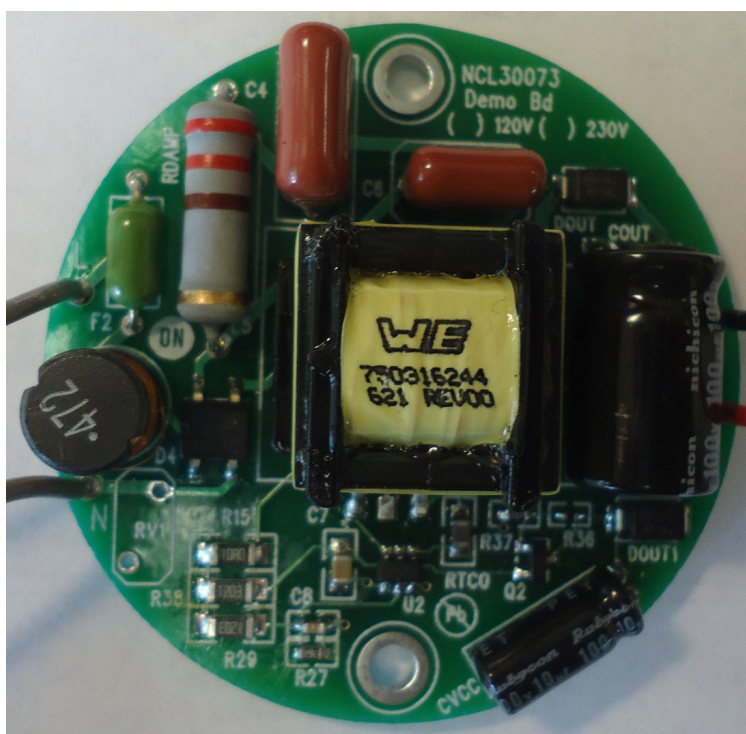


Figure 1. Evaluation Board Photo

## THEORY OF OPERATION

**Power Stage**

The power stage is a flying buck boost design. In this configuration, drain of the switching FET is connected to the rectified HVDC and the source is switching. This has many benefits:

1. Direct output current sensing
2. Direct output voltage sensing
3. No Aux winding needed

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.

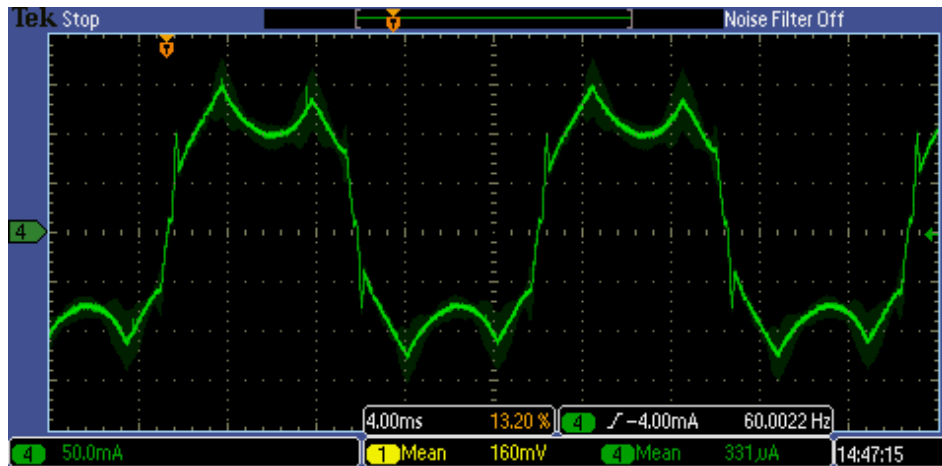


Figure 2.

**Output Voltage Sense and Vcc generation**

Dout1 is in parallel with the output during the off time of the FET and stores energy in C<sub>vcc</sub>. R36 and R37 divide the output voltage and Q2 buffers it to provide V<sub>cc</sub> power to the controller. Since the divider is a fixed ratio, V<sub>cc</sub> is a fixed percentage of the output voltage. When V<sub>cc</sub> rises above 25 V, the controller detects an OVP fault. The maximum output voltage is set by adjusting the ratio of R36/R37.

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 C<sub>vcc</sub> 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*

R<sub>tco</sub> is a PTC connected between the CS pin and R<sub>sens</sub>. The controller creates an internal signal current from the CS pin. As the resistance of R<sub>tco</sub> becomes larger with

temperature, the signal level at the CS pin increases causing the current to foldback with temperature.

*Programmable OVP*

R36 and R37 set V<sub>cc</sub> as a fixed percentage of the output voltage. The OVP threshold on the controller is 25 V. So the ratio of R36/R37 is set to trip the V<sub>cc</sub> OVP threshold at about 100 V output.

*Overcurrent Protection*

The controller has built-in overcurrent limits.

*Output Current*

The output current is set by the value of R<sub>sens</sub>. It's possible to adjust the output current by changing R<sub>sens</sub>.

**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.

# NCL30073LED3GEVB

## SCHEMATIC

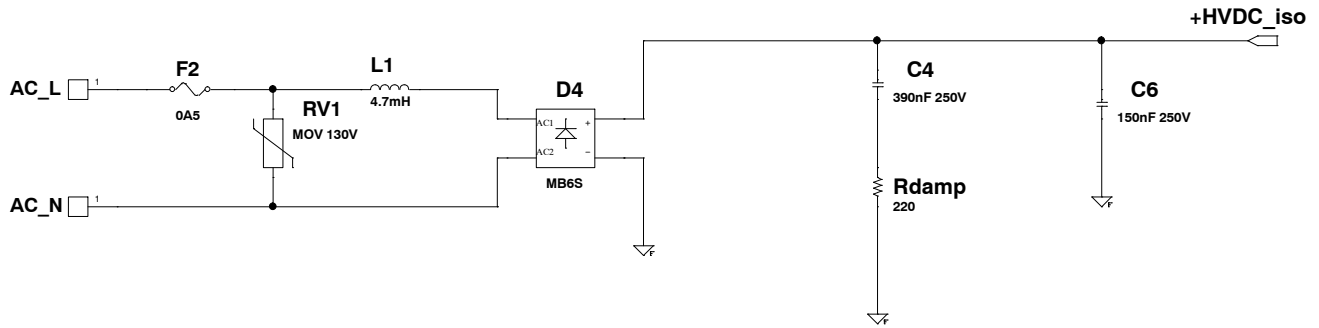


Figure 3. Input Circuit

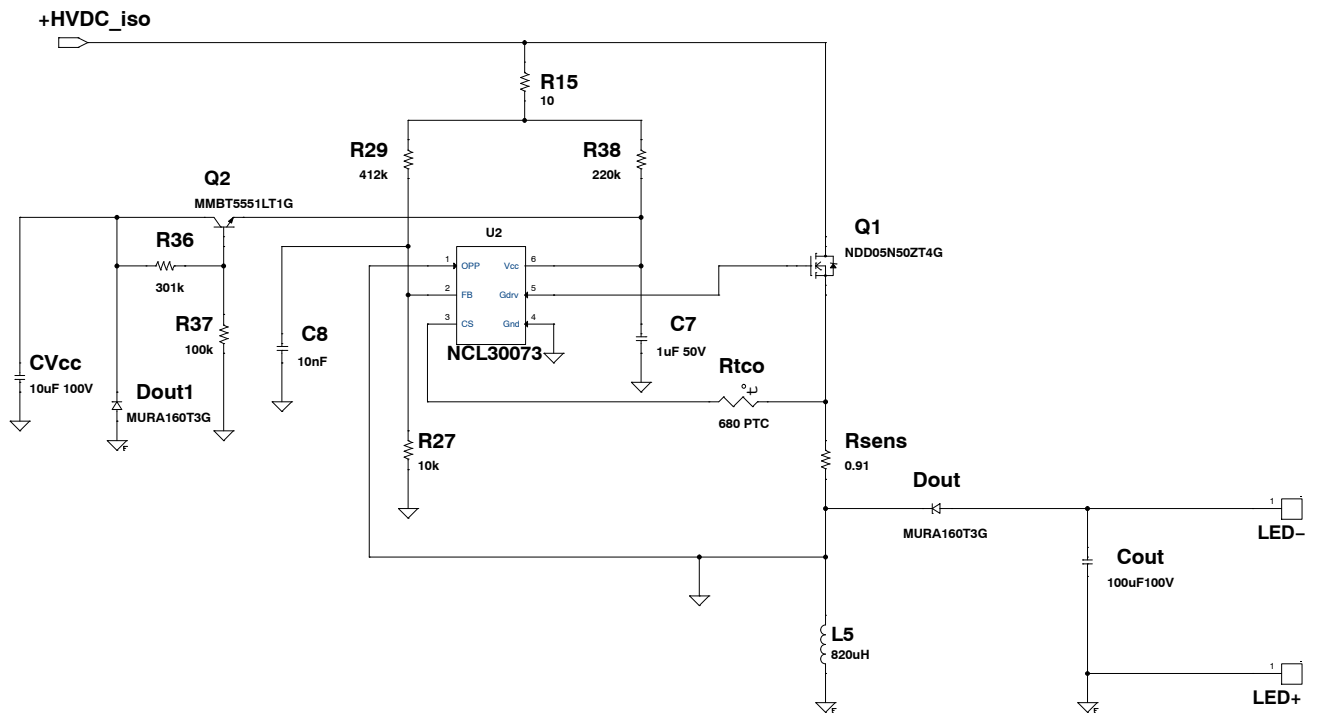


Figure 4. Main Circuit

# NCL30073LED3GEVB

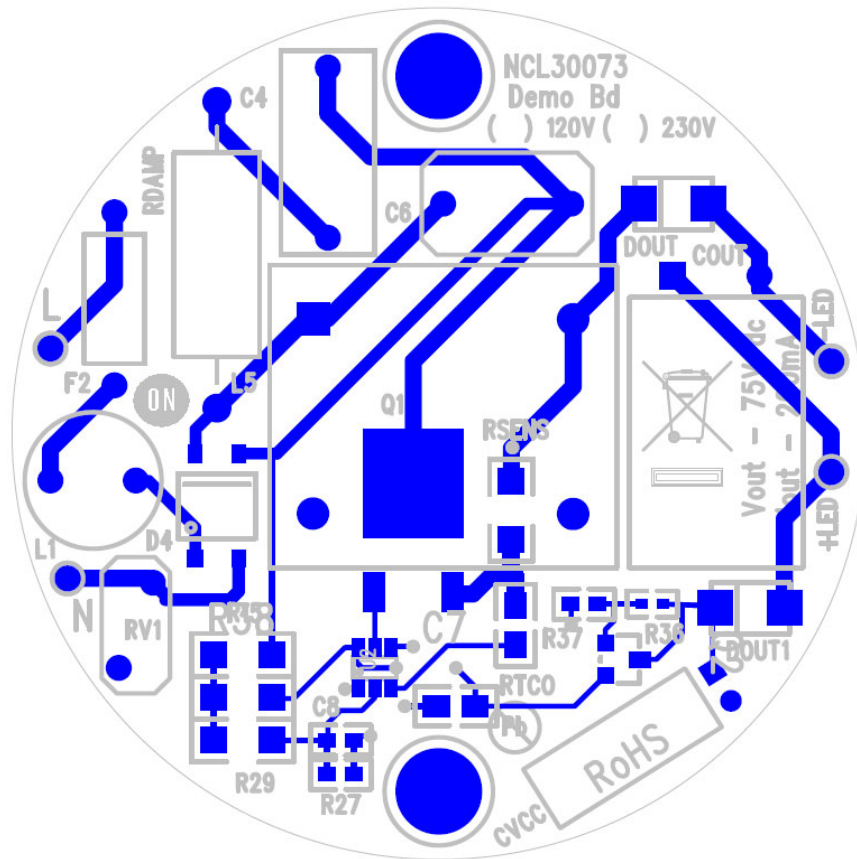
## BILL OF MATERIAL

**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   | 100 $\mu$ F 100 V | Nichicon         | UVK2A101MPD             | Digikey          | UVK2A101MPD-ND           | Yes                  |
| C4             | 1   | 390 nF 250 V      | Faratronic       | C252E394-6B****++       | Faratronic       | C252E394-6B****++        | Yes                  |
| C6             | 1   | 150 nF 250 V      | Faratronic       | C252E154-3B****++       | Faratronic       | C252E154-3B****++        | 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                  |
| Dout1,<br>Dout | 2   | MURA160T3G        | ON Semiconductor | MURA160T3G              | ON Semiconductor | MURA160T3G               | No                   |
| D4             | 1   | MB6S              | MCC              | MB6S                    | Digikey          | MB4S-TPMSCT-ND           | Yes                  |
| F2             | 1   | 0A5               | Littelfuse       | 0263.500WRT1L           | Digikey          | F1999CT-ND               | Yes                  |
| L1             | 1   | 4.7 mH            | Würth            | 744772472               | Digikey          | 732-3790-ND              | Yes                  |
| L5             | 1   | 820 $\mu$ H       | Würth            | 750316244               | Würth            | 750316244                | Yes                  |
| Q1             | 1   | NDD05N50ZT4G      | ON Semiconductor | NDD05N50ZT4G            | ON Semiconductor | NDD05N50ZT4G             | No                   |
| Q2             | 1   | MMBT5551LT1G      | ON Semiconductor | MMBT5551LT1G            | ON Semiconductor | MMBT5551LT1G             | No                   |
| RV1            | 1   | MOV 130V          | Littelfuse       | V220ZA05P               | Digikey          | F3049-ND                 | Yes                  |
| Rdamp          | 1   | 220               | Yageo            | RSF200JB-73-220R        | Digikey          | 220W-2-ND                | Yes                  |
| Rsens          | 1   | 0.91              | Yageo            | PT1206FR-7W0R91L        | Digikey          | 311-0.91APCT-ND          | Yes                  |
| Rtco           | 1   | 680 PTC           | Epcos            | B59721A90A62            | Digikey          | 495-4312-1-ND            | Yes                  |
| R15            | 1   | 10                | Yageo            | RC1206FR-0710RL         | Digikey          | 311-10.0FRCT-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                  |
| R36            | 1   | 301k              | Yageo            | RC0603FR-07301KL        | Digikey          | 311-301KHRCT-ND          | Yes                  |
| R37            | 1   | 100k              | Yageo            | RC0603FR-07100KL        | Digikey          | 311-100KHRCT-ND          | Yes                  |
| R38            | 1   | 220k              | Yageo            | RC1206FR-07220KL        | Digikey          | 311-220KFRCT-ND          | Yes                  |
| U2             | 1   | NCL30073          | ON Semiconductor | NCL30073                | ON Semiconductor | NCL30073                 | No                   |

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

## GERBER VIEWS



**Figure 5. Top Side PCB**

# NCL30073LED3GEVB

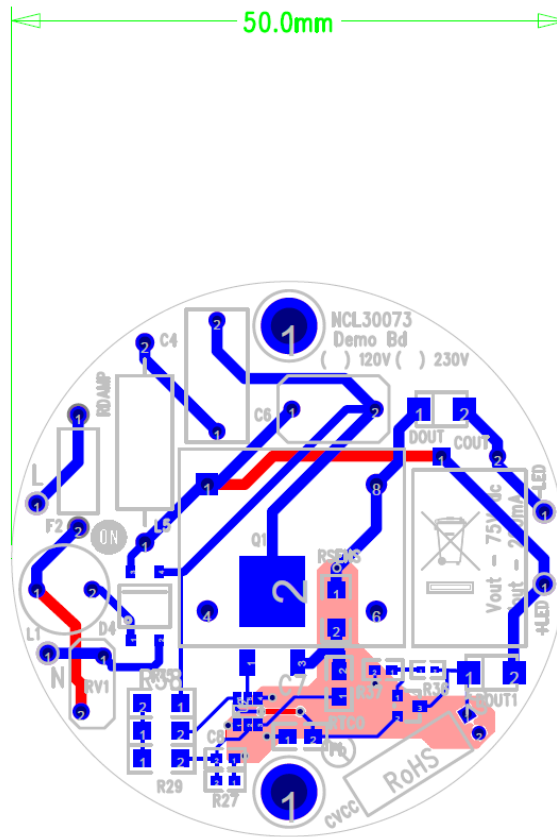


Figure 6. PCB Outline

## 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.

## NCL30073LED3GEVB

### ECA PICTURES

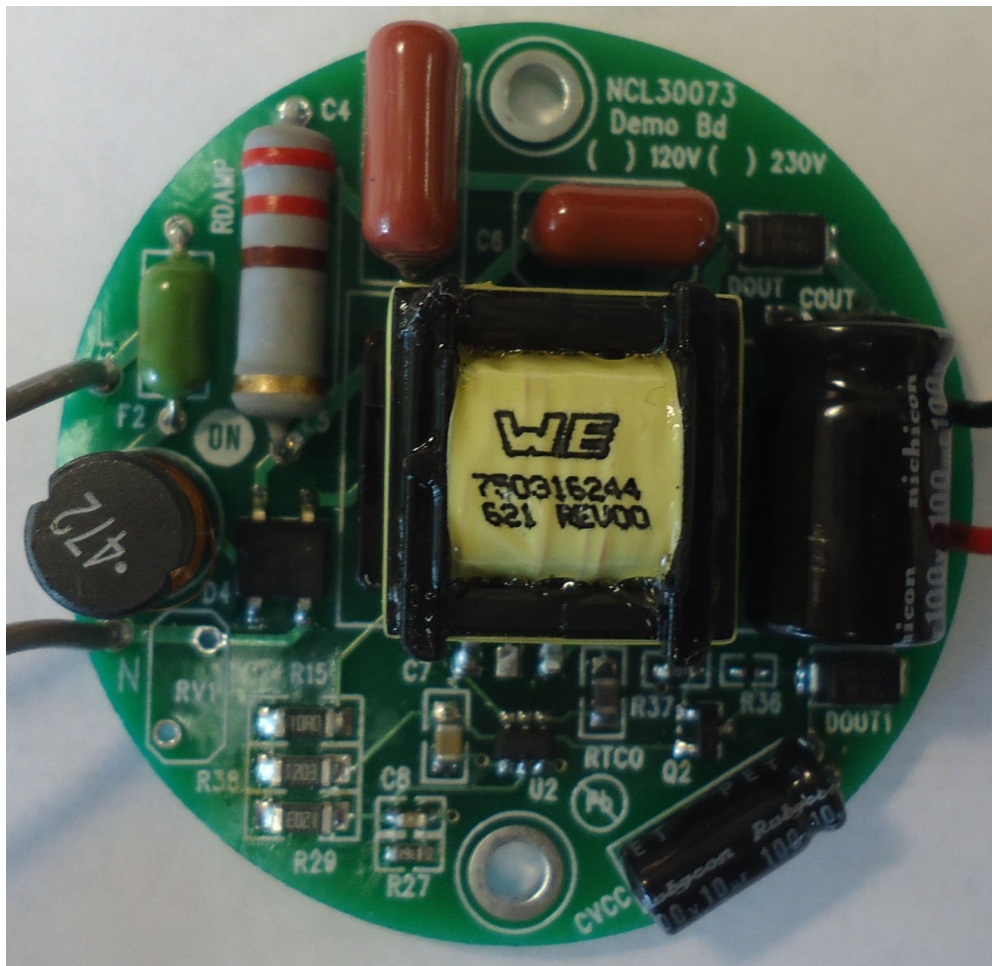


Figure 7. Top View



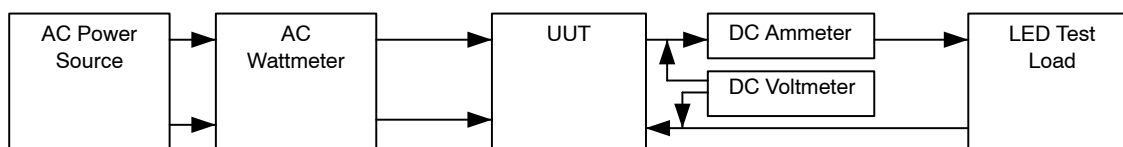
## TEST PROCEDURE

### Equipment Needed

- AC Source – 90 to 140 V ac 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 – 70 V – 80 V @ 110 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 75 V output.
2. Set the input power to 120 V 60 Hz.

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

### Regulation

120 V / Max Load

Table 3.

|       | Output Current | Output Power | Power Factor | THD |
|-------|----------------|--------------|--------------|-----|
| 108 V |                |              |              |     |
| 120 V |                |              |              |     |
| 132 V |                |              |              |     |

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



# NCL30073LED3GEVB

## TEST DATA

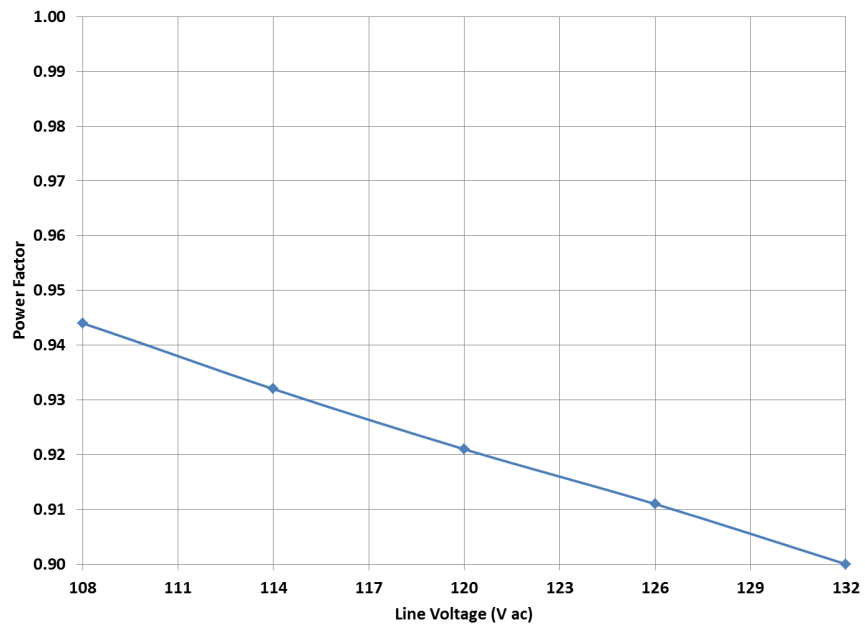


Figure 9. Power Factor Over Line

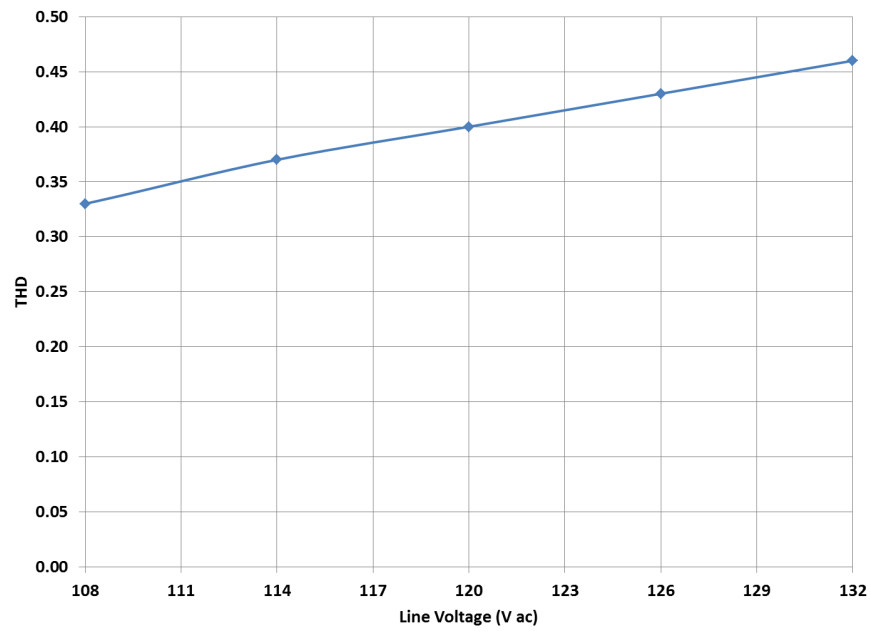


Figure 10. THD Over Line

## NCL30073LED3GEVB

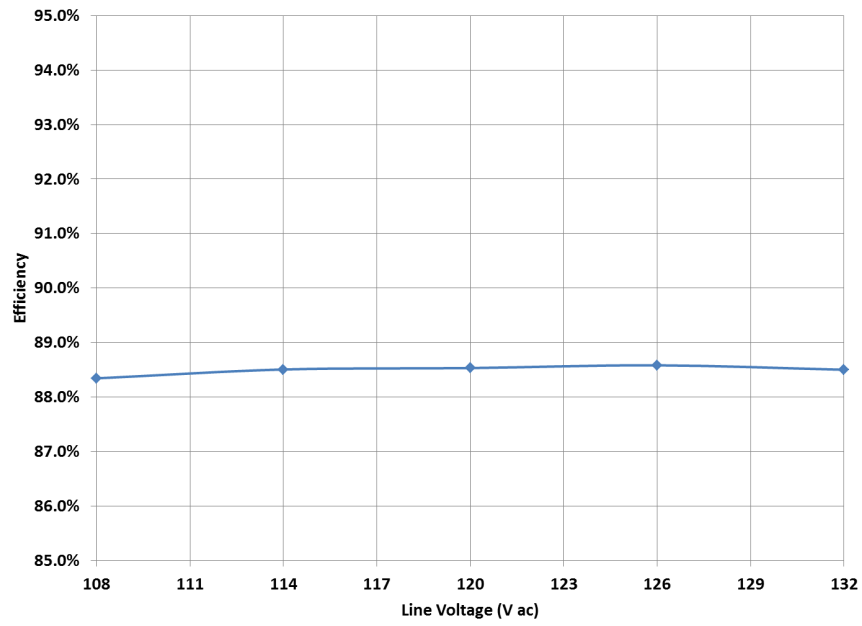


Figure 11. Efficiency

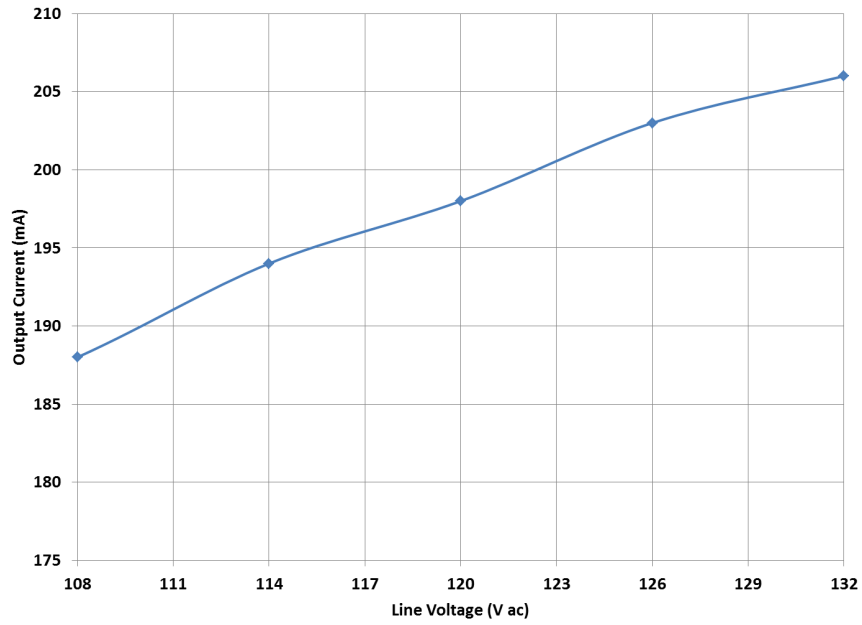


Figure 12. Regulation Over Line

# NCL30073LED3GEVB

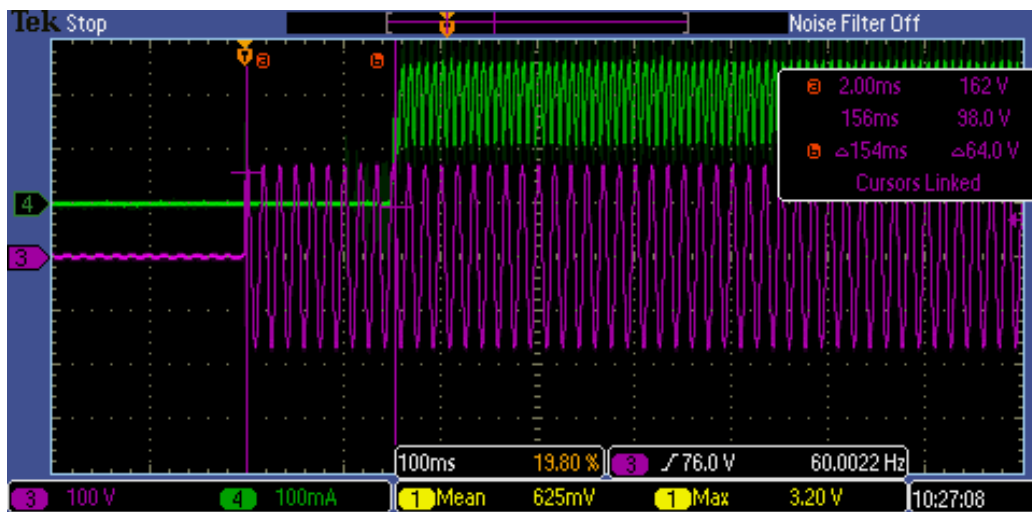


Figure 13. Start Up with AC Applied 120 V



Figure 14. Output Ripple 75% Pk - Pk

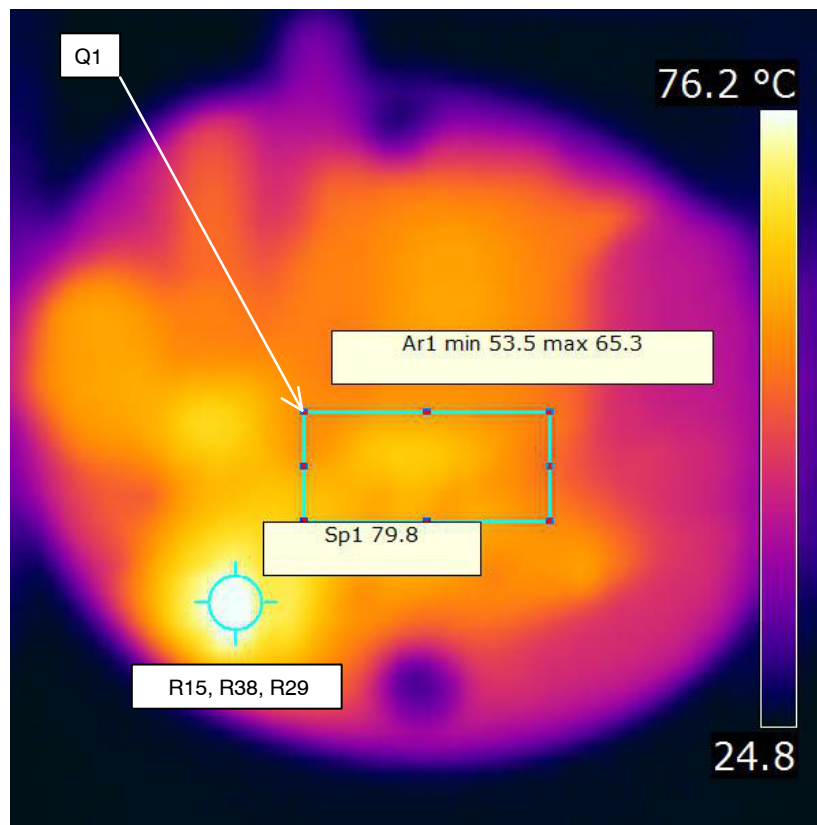


Figure 15. Thermal Image SMT Side

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