

# NCL30030GEVB

## 150 W High Performance 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 NCL30030GEVB evaluation board. The NCL30030 board demonstrates a 150 W high performance LED driver intended for commercial/ industrial applications. The NCL30030 combines a CrM PFC boost converter and a QR flyback converter in a single controller. An integrated HV start up is included in the NCL30030.

Table 1. SPECIFICATIONS

| Parameter                                | Value                  | Comment   |
|------------------------------------------|------------------------|-----------|
| Input voltage (Class 2 Input, no ground) | 90 – 305 V ac          |           |
| Line Frequency                           | 50 Hz / 60 Hz          |           |
| Power Factor (Load > 50%)                | 0.9                    |           |
| THD (Load > 30%)                         | 20%                    | Max       |
| Class 1 Output Mains Isolated            |                        |           |
| Output Voltage Range                     | 60 – 210 V dc          |           |
| "Off" Mode CV Output Voltage             | 50 V dc                |           |
| Output Current                           | 710 mA dc              | ±2%       |
| Output Ripple                            | 50 mA P-P              |           |
| Efficiency                               | 90%                    | Typical   |
| Start Up Time                            | < 300 ms               | Typical   |
| EMI (conducted)                          | Class A                | FCC/CISPR |
| Dimensions                               | 55 mm × 220 mm × 33 mm |           |

#### Key Features

As illustrated, the key features of this evaluation board include:

- Wide Mains including Support for 277 V ac US Commercial Line Voltage
- Low THD across Line and Load
- High Power Factor across Wide Line and Load
- Remote On/Off (Mains Isolated)
- Integrated Auto-recovery Fault Protection (can be latched by Choice of Options)
  - ♦ On Board Over Temperature Shutdown via NCL30030 Fault Input Pin
  - ♦ LED Module Over Temperature Foldback Input (a remote PTC on LED Array)
  - ♦ Over Voltage
- CC/CV Modes
- Can be Configured for several Dimming Modes
  - ♦ 1 – 10 V dc
  - ♦ 0 – 5 V dc Analog
  - ♦ 0 – 5 V PWM
  - ♦ Bi-level



Figure 1. Evaluation Board Picture (Top View)

## THEORY OF OPERATION

### PFC

The boost topology is the most common converter type for high performance power factor correction. Since this boost converter operates in CrM, the peak to average input current is always a 2:1 ratio. The converter operates in peak current

control rather than on time control or average current control. CrM boost converters typically have fidelity issues near the zero crossing of the AC line. This is a natural consequence of parasitics in the power stage. See a typical CrM inductor current in Figure 2.

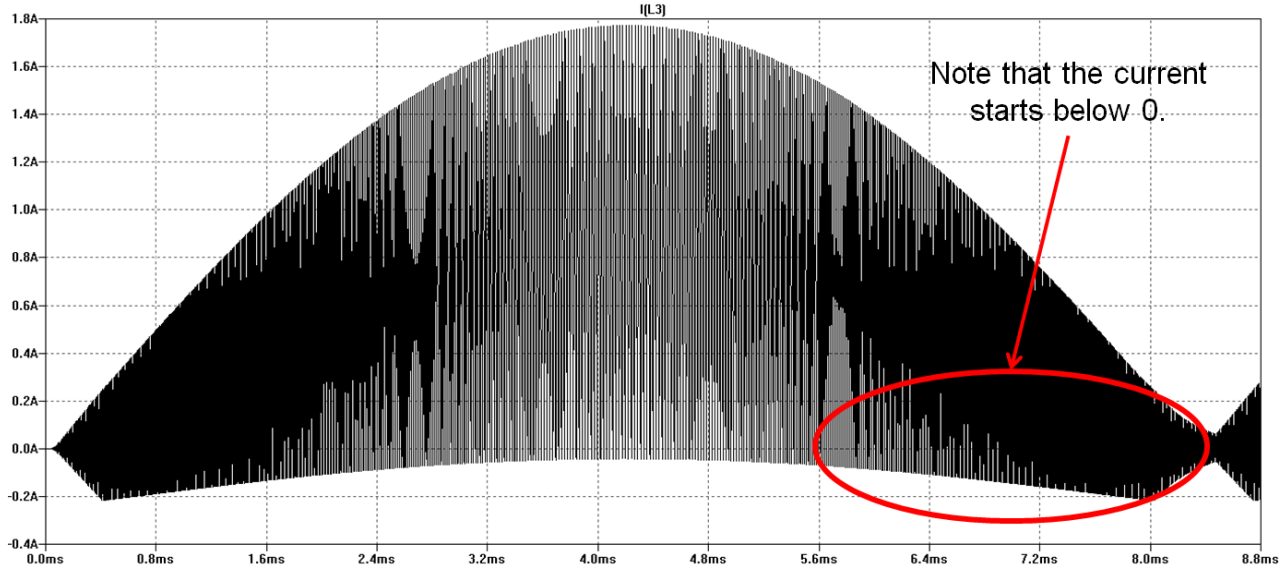


Figure 2. Inductor Current across a Line Cycle

Near the zero crossings, the current starts below zero current. This is a real effect of energy stored in the capacitance of the FET drain that does not get transferred to

the output capacitor. The consequence for on time controllers is that the target peak current is never reached in the on time which results in distortion at the zero crossing.

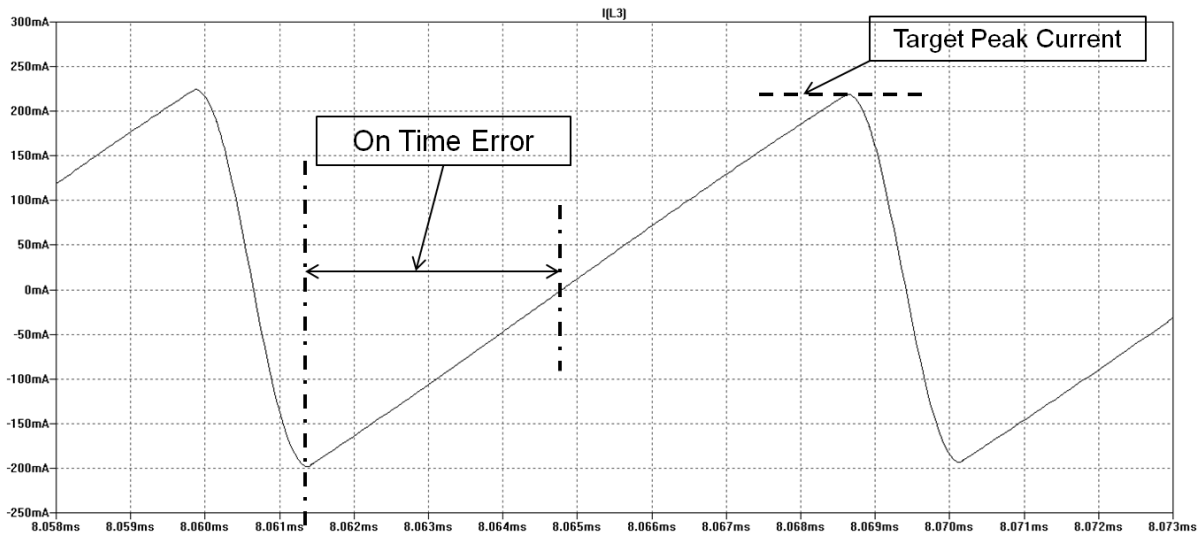


Figure 3. One Switching Cycle of Boost Inductor Current (simulated)

Peak current control corrects the on time error because the on time is dependent on the peak current. This will naturally increase on time at the zero crossing which reduces total harmonic distortion (THD).

The error amplifier adjusts the gain of a PWM multiplier to set the peak current threshold in the controller. The

multiplier output needs to be filtered to recover the scaled current threshold signal. The value of the filter capacitor is critical to obtain good THD over the entire line range. The filter capacitor must be large enough to filter the PWM carrier frequency but not so large as to cause excess phase lag which will degrade the THD.

## Bi-Level Boost Follower

The HV pin provides start up current for the controller and sense the HVDC voltage. The boost output reference for the control loop is adjusted based on the input voltage. There are 3 options for this: 2:1, 1.77:1, and 1:1 (i.e. fixed output voltage). This allows the boost converter to operate most efficiently over a broad range of input voltages.

## Current Sense and ZCD

The current sense and ZCD are combined on one pin as illustrated in Figure 5. During the switch on time, the peak current is sensed through R24. D11 blocks the negative voltage from the sense winding from affecting the current sense. During the off time, D11 forward biases and pull the pin high through R26. Collapsing voltage on the boost inductor signals that the current has gone to zero and starts a new switch cycle.

## Flyback

The flyback converter isolates the output from the mains and provides power for the secondary side control. For this specific design given the high output voltage of the PFC Bus rail and the high voltage range of the output, a two switch flyback configuration was selected. The two switch operation for the flyback optimizes efficiency because the leakage energy is recycled back to the primary energy storage. One limitation of the two switch flyback is that the reflected output voltage must be less than the input voltage otherwise all of the stored energy in the transformer will be returned to the input energy storage. Since the turns ratio is 1:1 and the maximum output voltage is 210 V, that condition is satisfied.

The converter operates in quasi-resonant mode. At heavy loads, the turn on edge is timed to the first valley like CrM mode. At progressively lighter loads, the controller moves the turn on edge to progressively higher order valleys. The voltage on the control determines the valley of operation. There are several important benefits of this technique.

1. The frequency is more stable over the load range
2. The peak current remains higher across load as the switching frequency is reduced. This keeps the signal-to-noise ratio high on the CS pin.

## Feedback Control

The NCL30030 has no internal error amplifier for the flyback control. The feedback pin directly programs the peak current and sets the valley selection. There is a current source that pulls up the FB pin. Consequently, the control is setup for secondary side feedback only.

## Connections to the Evaluation Board

There are several connections necessary to operate the evaluation board.

- AC Input – J1 3 Pin Connector
  1. AC Line
  2. nc
  3. AC Neutral
- LED Output – J2 3 Pin Connector
  1. LED +
  2. nc
  3. LED–
- Control – J3 7 Pin Connector
  1. 10 V
  2. 1–10 V Dimming
  3. 0–5 V Analog or Digital PWM Dimming
  4. Lamp TCO
  5. Bi-level Dimming
  6. On–Off
  7. Common

## Control Connections

### 10V

This connection provides a current limited 10 V source which can be used to power the dimming interface. Current is limited to 10 mA through a 1 k $\Omega$  resistor.

### LED Lamp TCO

The LED assembly may have a PTC that “opens” when the LED assembly exceeds a safe temperature. The cold value of the PTC should be approximately 470  $\Omega$  and the transition resistance should be greater than 5 k $\Omega$ . The action of the TCO folds back the output current to maintain the temperature at a safe level but does not turn the LEDs completely off.

NOTE: Connect the Lamp TCO connection to common if a TCO is not used.

### On–Off

The driver can be turned “off” from the secondary side. An open on the on–off connection defaults to “off”. Connect the on–off connection to common to turn on the driver. Off mode operates the output in a low voltage (50 V) CV mode such that the output voltage is below the LED operational voltage.

### Dimming Control Mode Setup

The evaluation board can be configured to support numerous dimming configurations; only one type of dimming is supported at a time. In addition to a 1–10 V Dimming interface, analog, digital and bi-level options are supported. Bi-level can be used in conjunction with motion sensors or timers to provide two light output levels depending on the use case.

**Table 2. CONFIGURING THE BOARD FOR DIMMING CONTROL**

| Connection      | Mode                    |                      |                                        |                                          |
|-----------------|-------------------------|----------------------|----------------------------------------|------------------------------------------|
|                 | 1 – 10 V                | 0 – 5 V Analog       | 0 – 5 V Digital                        | Bi-Level                                 |
| 1 – 10 V        | 1 – 10 V Analog Voltage | Open                 |                                        | Open                                     |
| 0 – 5 V Analog  | Open                    | 0 – 5 Analog Voltage | N/A                                    | Open                                     |
| 0 – 5 V Digital |                         | N/A                  | 0 – 5 V Digital Input<br>Freq > 400 Hz | Open                                     |
| Bi-level        | Open                    | Open                 |                                        | Open = High Current<br>GND = Low Current |

**Modifications**

It is possible for the user to select different operating conditions for the evaluation board such as output current, over voltage threshold, and over temperature threshold.

**Output Current**

R9 and R44 set the output current. R44 is a trim resistor to make fine adjustments to the current set point. The reference voltage for U2 is 62.5 mV.  $I_{\text{output}}$  is calculated as follows:

$$I_{\text{output}} = \frac{62.5 \text{ mV} \times (R9 + R44)}{R9 \times R44}$$

The low reference voltage makes even the copper PCB trace resistance important in setting the output current. There are limitations to setting the current without making major component changes. Generally the current can be adjusted from 0.5 A – 1.0 A.

**CV Regulation**

As illustrated in Figure 7, the NCP4328A (U2) also serves as the CV regulator loop control. R12, R13, R14, and R28 set the CV output. As built, the evaluation board CV point is 210 V dc. The reference voltage for the CV loop is 1.25 V. R13 and R28 are in parallel. Their equivalent resistance is:

$$R_{\text{eq}} = \frac{R13 \times R28}{R13 + R28}$$

CV regulation is calculated as follows:

$$\text{CV} = \frac{R13 + R_{\text{eq}} + R14}{R_{\text{eq}}} \times 1.25 \text{ V}$$

**Over Voltage Protection**

Zener D19 is used to set the primary side over voltage fault protection level. As built, the CV loop will prevent an OV fault under normal circumstances. D19 pulls up the fault pin on U1 to trigger a fault. The fault shuts down U1 for 4 seconds and then recycles the fault latch. A non-resetting latch is an option for U1. The set point for the trip point is calculated as follows:

$$\text{OV} = \frac{V_{\text{d19}}}{30\%}$$

D19 must be replaced to change the OV threshold.

**Thermal Protection**

The evaluation board has an onboard thermal shutdown utilizing the NTC R3 connected to the fault pin of U1. As R3 heats, the output current will shut off until the NTC cools down. R3 can be replaced with a fixed resistor if no thermal protection is desired.

# NCL30030GEVB

## SCHEMATIC

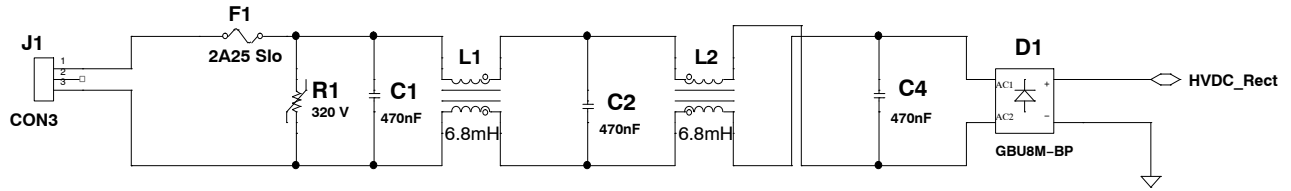


Figure 4. Input Circuit

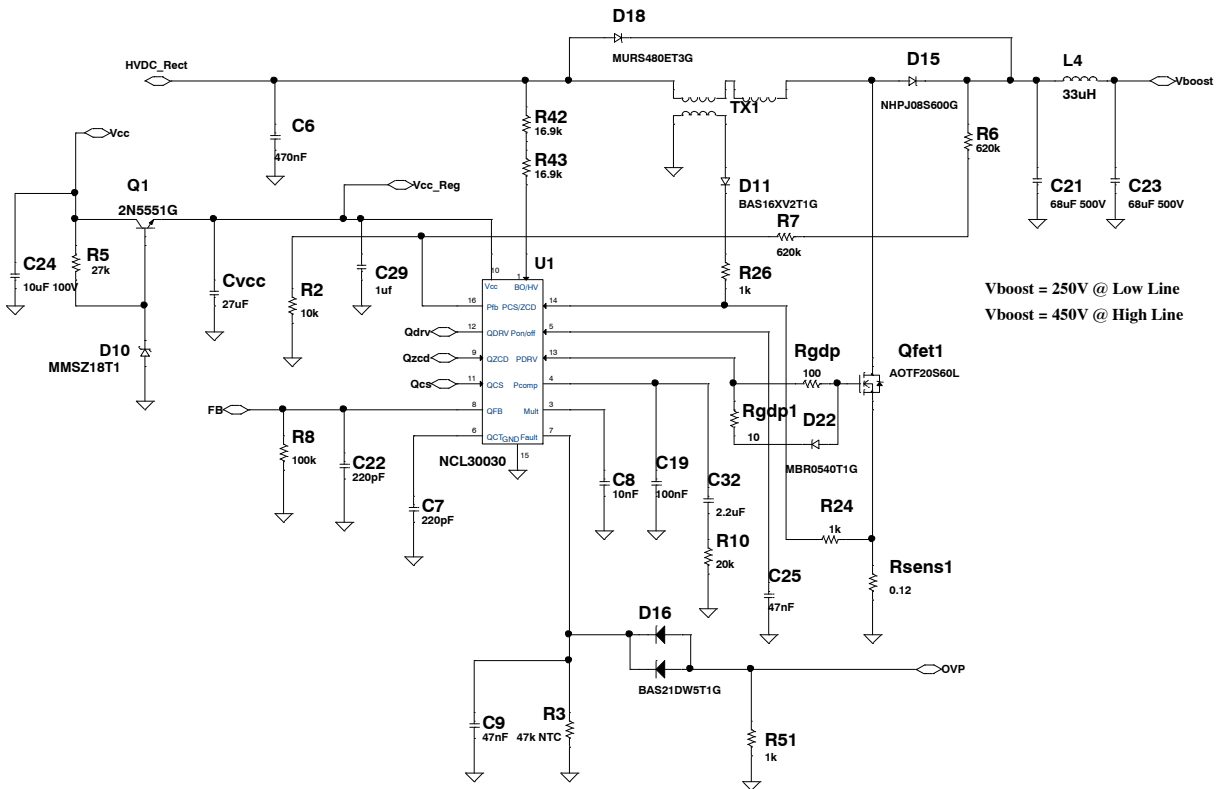


Figure 5. PFC Schematic

The schematic diagram illustrates a power management IC (PMIC) with the following components and connections:

- Power Input/Output:**
  - Vboost:** Boost input terminal.
  - Vcc\_Reg:** Regulated VCC input.
  - Qdrv:** Driver output terminal.
  - Qzcd:** Zero-current detect input.
  - OVP:** Over-voltage protection input.
  - Vcc:** Main power input.
  - Qdrv\_LO:** Driver output (LO) terminal.
  - Qcs:** Current sense input.
- Control and Monitoring:**
  - Dboot:** Boot control input.
  - Qdrv\_LO:** Driver output (LO) terminal.
  - Qzcd:** Zero-current detect input.
  - OVP:** Over-voltage protection input.
  - Vcc:** Main power input.
  - Qdrv\_LO:** Driver output (LO) terminal.
  - Qcs:** Current sense input.
- Internal Blocks and Components:**
  - U12:** NCP5106ADR2G (PMIC core).
  - Qfet2:** AOTF20S60L (MOSFET).
  - T1:** Transformer (1:1 ratio).
  - Q2:** 2N5551G (NPN transistor).
  - U11:** TL431 (Precision centrer).
  - D20:** UFM15PL (Diode).
  - D19:** MMSZ5267BT1G (Zener diode).
  - D25:** BAT54T1G (Diode).
  - D12:** UFM15PL (Diode).
  - D21:** MURA160T3G (Diode).
  - D13:** MURA160T3G (Diode).
  - D4:** UFM15PL (Diode).
  - D2:** STTH810FP (Diode).
- Resistors:**
  - R57:** 100Ω
  - R25:** 10kΩ
  - R32:** 2.49kΩ
  - R27:** 2.49kΩ
  - R23:** 7.50kΩ
  - R54:** 10Ω
  - R58:** 10Ω
  - R4:** 1kΩ
  - R53:** 10Ω
  - R50:** 10kΩ
  - R5:** 0.25Ω
- Capacitors:**
  - C33:** 1μF
  - C35:** 1nF
  - C34:** 220pF 1kV
  - C14:** 4.7μF 250V
  - C18:** 10μF 100V
  - C17:** 10nF Y1
  - C26:** 220pF 1kV
  - C27:** 22pF
  - C30:** 22μF 50V
  - C36:** 100pF
- Other Components:**
  - LED+:** LED anode output.
  - LED\_rtn:** LED common return.
  - V10:** Output terminal.

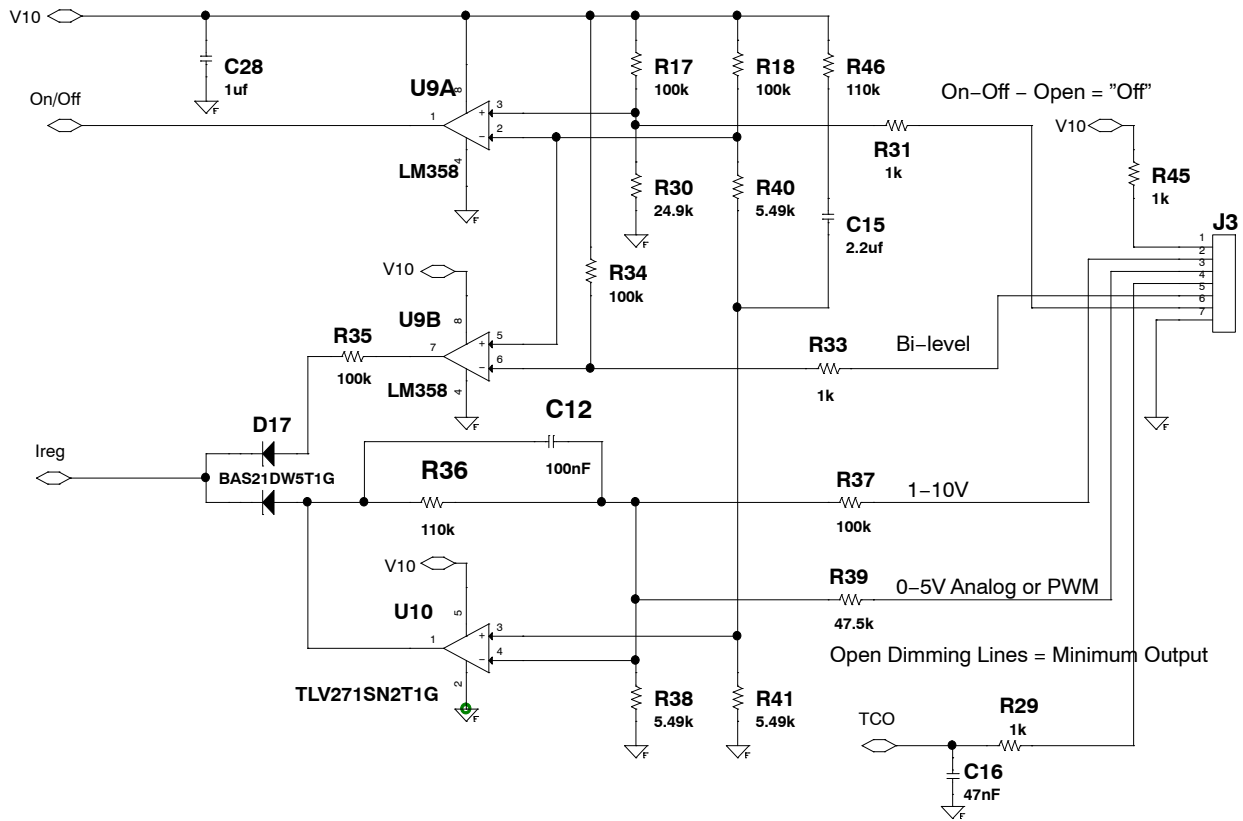
The schematic diagram illustrates a 50W LED driver circuit. Key components and their values are as follows:

- Inductor:** L3, 100uH
- Resistors:**
  - R44: 1.5
  - R9: 0.09
  - R52: 4.7k 1W
  - R14: 604k
  - R12: 604k
  - R22: 1k
  - R19: 3.32k
  - R48: 10k
  - R16: 1k
  - R28: 63.4k
  - R47: 10k
  - R13: 8.06k
  - R15: 165k
  - R20: 10k
  - R21: 160k
  - R49: 10k
  - R11: 100k
- Capacitors:**
  - C37: 220pF
  - C10: 4.7nF
  - C11: 100nF
  - C13: 4.7nF
- Transistors:**
  - Qfet3: BSS127S-7
  - U6: FOD817A3SD
  - U2A: NCP4328A
  - U7A: NCP4328A
- Diode:** D14: BAS21DW5T1G
- Other Labels:**
  - LED+, LED\_rtn
  - Iset = 700mA
  - Active Preload
  - On/Off
  - V10
  - FB
  - 50V out = "off"
  - On/Off
  - Ireg
  - Overtemp Foldback
  - TCO
  - J2, CON3

The circuit includes a Voltage Control Loop (OVP = 210 V) and a Current Control Loop. It also features an Overtemp Foldback mechanism and an Active Preload section.

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**Figure 8. Dimming Interface**

## BILL OF MATERIAL

**Table 3. BILL OF MATERIAL\***

| Qty | Reference        | Part       | Manufacturer | Mfr_PN            | PCB Footprint          | Substitutions Allowed |
|-----|------------------|------------|--------------|-------------------|------------------------|-----------------------|
| 1   | Cvcc             | 27uF       | Panasonic    | EEU-FC1E270       | CAP_AL_5X11            | Yes                   |
| 4   | C1,C2,C4, C6     | 470nF      | Epcos        | B32923C3474K      | CAP-BOX-LS22M5-26MX7M  | Yes                   |
| 3   | C7,C22, C37      | 220pF      | Yageo        | CC0805JRNPO9BN221 | 805                    | Yes                   |
| 1   | C8               | 10nF       | AVX          | 0805YA103JAT2A    | 805                    | Yes                   |
| 3   | C9,C16, C25      | 47nF       | Yageo        | CC0805KRX7R9BB473 | 805                    | Yes                   |
| 2   | C10,C13          | 4.7nF      | Yageo        | CC0805KRX7R9BB472 | 805                    | Yes                   |
| 3   | C11,C12, C19     | 100nF      | Yageo        | CC0805KRX7R9BB104 | 805                    | Yes                   |
| 1   | C14              | 4.7uF 250V | Panasonic    | ECQ-E2475KB       | CAP-BOX-LS175-8M5X18   | Yes                   |
| 1   | C15              | 2.2uf      | Taiyo Yuden  | UMK212BB7225KG-T  | 805                    | Yes                   |
| 1   | C17              | 10nF Y1    | Vishay       | 440LS10-R         | Cap_disc_20mm          | Yes                   |
| 2   | C18,C24          | 10uF 100V  | Rubycon      | 100PK10MEFC5X11   | CAP_AL_5X11            | Yes                   |
| 1   | C21              | 68uF 500V  | Nichicon     | UCY2H680MHD       | CAP-ALEL-18X42-HOR-REV | Yes                   |
| 1   | C23              | 68uF 500V  | Nichicon     | UCY2H680MHD       | CAP-ALEL-18X42-HOR     | Yes                   |
| 2   | C26,C34          | 220p 1kV   | Kemet        | R76QD0220SE00J    | CAP-BOX-LS5-3M5X7M2    | Yes                   |
| 1   | C27              | 22pF       | Yageo        | CC0805JRNPO9BN220 | 805                    | Yes                   |
| 4   | C28,C29, C31,C33 | 1uf        | Yageo        | CC0805KX7R8BB105  | 805                    | Yes                   |
| 1   | C30              | 22uF 50V   | Rubycon      | 50YXM22MEFC5X11   | CAP_AL_5X11            | Yes                   |
| 1   | C32              | 2.2uF      | Yageo        | CC0805KX7R6BB225  | 805                    | Yes                   |

\*All Components to be RoHS Compliant

# NCL30030GEVB

**Table 3. BILL OF MATERIAL\***

| Qty | Reference                                 | Part         | Manufacturer     | Mfr_PN            | PCB Footprint  | Substitutions Allowed |
|-----|-------------------------------------------|--------------|------------------|-------------------|----------------|-----------------------|
| 1   | C35                                       | 1nF          | Yageo            | CC0805JRNPO9BN102 | 805            | Yes                   |
| 1   | C36                                       | 100pF        | Yageo            | CC0805JRNPO9BN101 | 805            | Yes                   |
| 3   | D13,D21, Dboot                            | MURA160T3G   | ON Semiconductor | MURA160T3G        | SMA            | No                    |
| 1   | Dout                                      | STTH810FP    | ST               | STTH810FP         | TO-220-2_vert  | Yes                   |
| 1   | D1                                        | GBU8M-BP     | MCC              | GBU8M-BP          | 4P_inline      | Yes                   |
| 3   | D4,D12, D20                               | UFM15PL      | MCC              | UFM15PL           | SOD123FL       | Yes                   |
| 1   | D10                                       | MMSZ18T1     | ON Semiconductor | MMSZ18T1          | SOD123FL       | No                    |
| 1   | D11                                       | BAS16XV2T1G  | ON Semiconductor | BAS16XV2T1G       | SOD523         | No                    |
| 3   | D14,D16, D17                              | BAS21DW5T1G  | ON Semiconductor | BAS21DW5T1G       | SC-88A         | No                    |
| 1   | D15                                       | NHPJ08S600G  | ON Semiconductor | NHPJ08S600G       | TO-220-UP      | No                    |
| 1   | D18                                       | MURS480ET3G  | ON Semiconductor | MURS480ET3G       | SMC            | No                    |
| 1   | D19                                       | MMSZ5267BT1G | ON Semiconductor | MMSZ5267BT1G      | SOD123FL       | No                    |
| 1   | D22                                       | MBR0540T1G   | ON Semiconductor | MBR0540T1G        | SOD123FL       | No                    |
| 1   | D25                                       | BAT54T1G     | ON Semiconductor | BAT54T1G          | SOD123FL       | No                    |
| 1   | F1                                        | 2A25 Slo     | Littelfuse       | 02092.25MXEP      | 15mm_axial     | Yes                   |
| 2   | J1,J2                                     | CON3         | Würth            | 6.91E+11          | Conn_3P_Scrmnt | Yes                   |
| 1   | J3                                        | CON7         | On Shore         | OSTTA074163       | Conn_7P_Scrmnt | Yes                   |
| 2   | L1,L2                                     | 6.8mH        | Würth            | 7.5E+08           | HOR-4P-19X10   | Yes                   |
| 1   | L3                                        | 100uH        | Würth            | 7.45E+08          | Rad_Ind_LS5    | Yes                   |
| 1   | L4                                        | 33uH         | Würth            | 7.45E+08          | Rad_Ind_LS5    | Yes                   |
| 3   | Qfet1,Qfet2, Qfet                         | AOTF20S60L   | AOS              | AOTF20S60L        | TO-220-3-Vert  | Yes                   |
| 1   | Qfet3                                     | BSS127S-7    | Diodes           | BSS127S-7         | SOT23          | Yes                   |
| 2   | Q1,Q2                                     | 2N5551G      | ON Semiconductor | 2N5551G           | TO92           | No                    |
| 2   | R57,Rgdp                                  | 100          | Yaego            | RC0805FR-07100RL  | 805            | Yes                   |
| 4   | Rgdp1,R53, R54,R58                        | 10           | Yaego            | RC0805FR-0710RL   | 805            | Yes                   |
| 1   | Rsens                                     | 0.25         | Vishay           | WSL2512R2500FEA   | 2512           | Yes                   |
| 1   | Rsens1                                    | 0.12         | Yaego            | RL2512FK-070R12L  | 2512           | Yes                   |
| 1   | R1                                        | 320 V        | Epcos            | S20K320E2         | MOV_20mm_disc  | Yes                   |
| 6   | R2,R20, R25,R47, R48,R49                  | 10k          | Yaego            | RC0805FR-0710KL   | 805            | Yes                   |
| 1   | R3                                        | 47k NTC      | Epcos            | B57431V2473J62    | 805            | Yes                   |
| 10  | R4,R16,R22,R24, R26,R29, R31,R33, R45,R51 | 1k           | Yaego            | RC0805FR-071KL    | 805            | Yes                   |
| 1   | R5                                        | 27k          | Yaego            | RC0805FR-0727KL   | 805            | Yes                   |
| 2   | R6,R7                                     | 620k         | Yaego            | RC1206FR-07620KL  | 1206           | Yes                   |
| 7   | R8,R11, R17,R18, R34,R35, R37             | 100k         | Yaego            | RC0805FR-07100KL  | 805            | Yes                   |
| 1   | R9                                        | 0.09         | Vishay           | WSL1206R0900FEA   | 1206           | Yes                   |
| 1   | R10                                       | 20k          | Yaego            | RC0805FR-0720KL   | 805            | Yes                   |
| 2   | R12,R14                                   | 604k         | Yaego            | RC1206FR-07604KL  | 1206           | Yes                   |
| 1   | R13                                       | 8.06k        | Yaego            | RC0805FR-078K06L  | 805            | Yes                   |
| 1   | R15                                       | 165k         | Yaego            | RC0805FR-07165KL  | 805            | Yes                   |
| 1   | R19                                       | 3.32k        | Yaego            | RC0805FR-073K32L  | 805            | Yes                   |
| 1   | R21                                       | 160k         | Yaego            | RC0805FR-07160KL  | 805            | Yes                   |
| 1   | R23                                       | 7.50k        | Yaego            | RC0805FR-077K5L   | 805            | Yes                   |
| 2   | R27,R32                                   | 2.49k        | Yaego            | RC0805FR-072K49L  | 805            | Yes                   |

\*All Components to be RoHS Compliant

# NCL30030GEVB

**Table 3. BILL OF MATERIAL\***

| Qty | Reference    | Part         | Manufacturer     | Mfr_PN           | PCB Footprint | Substitutions Allowed |
|-----|--------------|--------------|------------------|------------------|---------------|-----------------------|
| 1   | R28          | 63.4k        | Yaego            | RC0805FR-0763K4L | 805           | Yes                   |
| 1   | R30          | 24.9k        | Yaego            | RC0805FR-0724k9L | 805           | Yes                   |
| 2   | R36,R46      | 110k         | Yaego            | RC0805FR-07110KL | 805           | Yes                   |
| 3   | R38,R40, R41 | 5.49k        | Yaego            | RC0805FR-075K49L | 805           | Yes                   |
| 1   | R39          | 47.5k        | Yaego            | RC0805FR-0747K5L | 805           | Yes                   |
| 2   | R42,R43      | 16.9k        | Yageo            | RC1206FR-0716K9L | 1206          | Yes                   |
| 1   | R44          | 1.5          | Yageo            | RC1206FR-071R5L  | 1206          | Yes                   |
| 1   | R50          | 10k          | Yaego            | RC1206FR-0710KL  | 1206          | Yes                   |
| 1   | R52          | 4.7k 1W      | Yageo            | RSF100JB-73-4K7  | 15MM_Axial    | Yes                   |
| 1   | TX1          | XFRM_LINEAR  | Würth            | 7.5E+08          | PQ2625-X12    | Yes                   |
| 1   | T1           | XFRM_LINEAR  | Würth            | 750314657 Rev3   | ER2817        | Yes                   |
| 1   | U1           | NCL30030     | ON Semiconductor | NCL30030B1DR2G   | SO16-P2       | No                    |
| 2   | U2,U7        | NCP4328A     | ON Semiconductor | NCP4328A         | TSOP-5        | No                    |
| 1   | U6           | FOD817A3SD   | Fairchild        | FOD817A3SD       | 4SMD          | Yes                   |
| 1   | U9           | LM358        | ON Semiconductor | LM358DR2G        | SO8M1         | No                    |
| 1   | U10          | TLV271SN2T1G | ON Semiconductor | TLV271SN2T1G     | SOT23-5       | No                    |
| 1   | U11          | TL431        | ON Semiconductor | TL431ACLPRAG     | TO92          | No                    |
| 1   | U12          | NCP5106ADR2G | ON Semiconductor | NCP5106ADR2G     | SO8M1         | No                    |

\*All Components to be RoHS Compliant

# NCL30030GEVB

## GERBER VIEWS

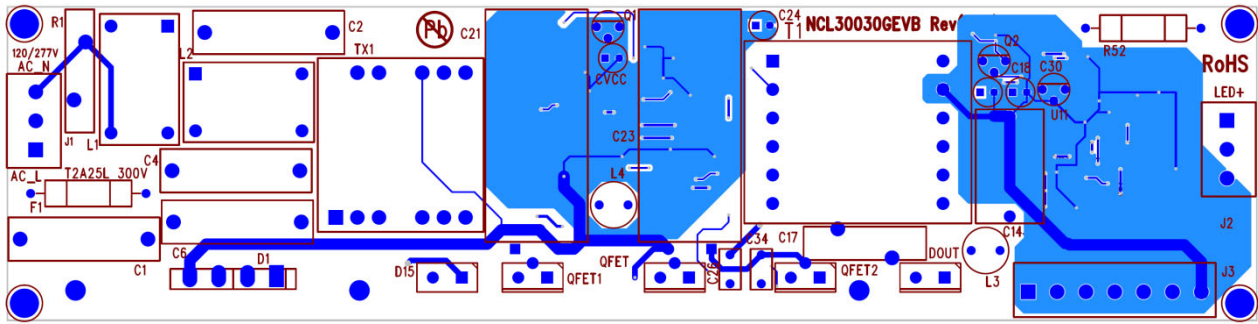


Figure 9. Top Side PCB

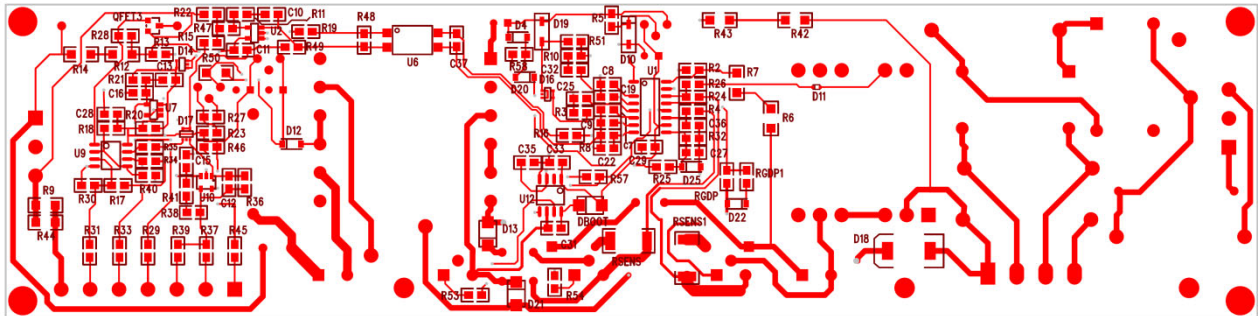


Figure 10. Bottom Side PCB

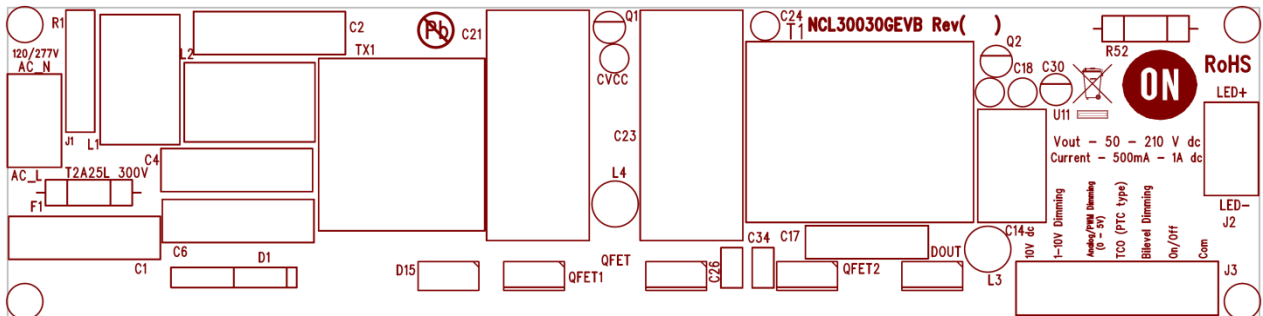


Figure 11. Top Silkscreen

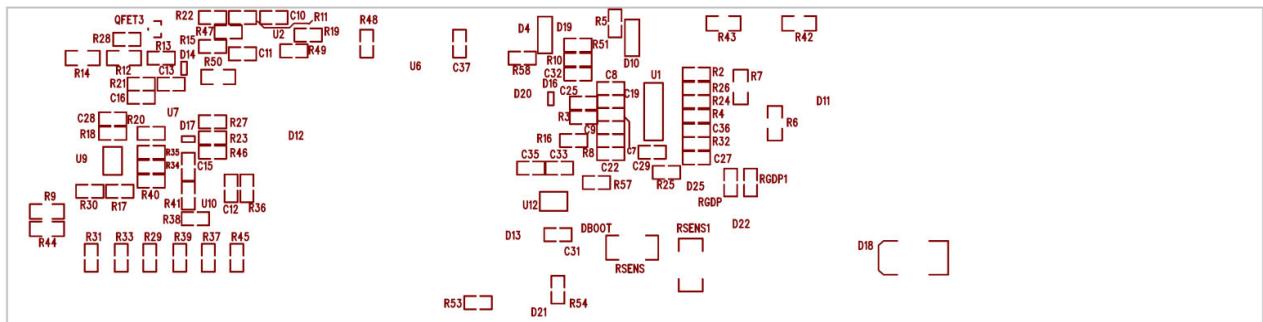


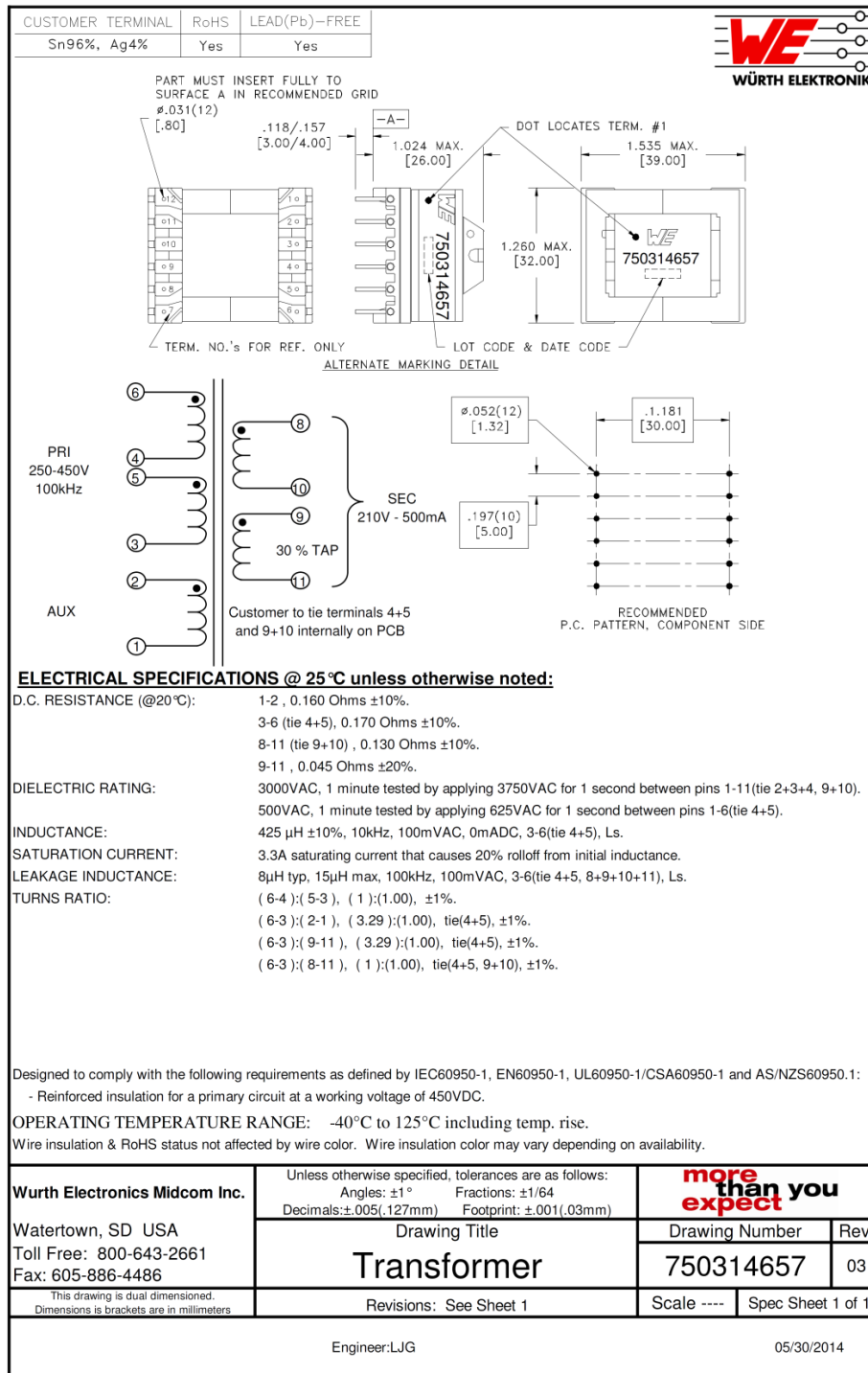
Figure 12. Bottom Silkscreen

**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 compliance required.

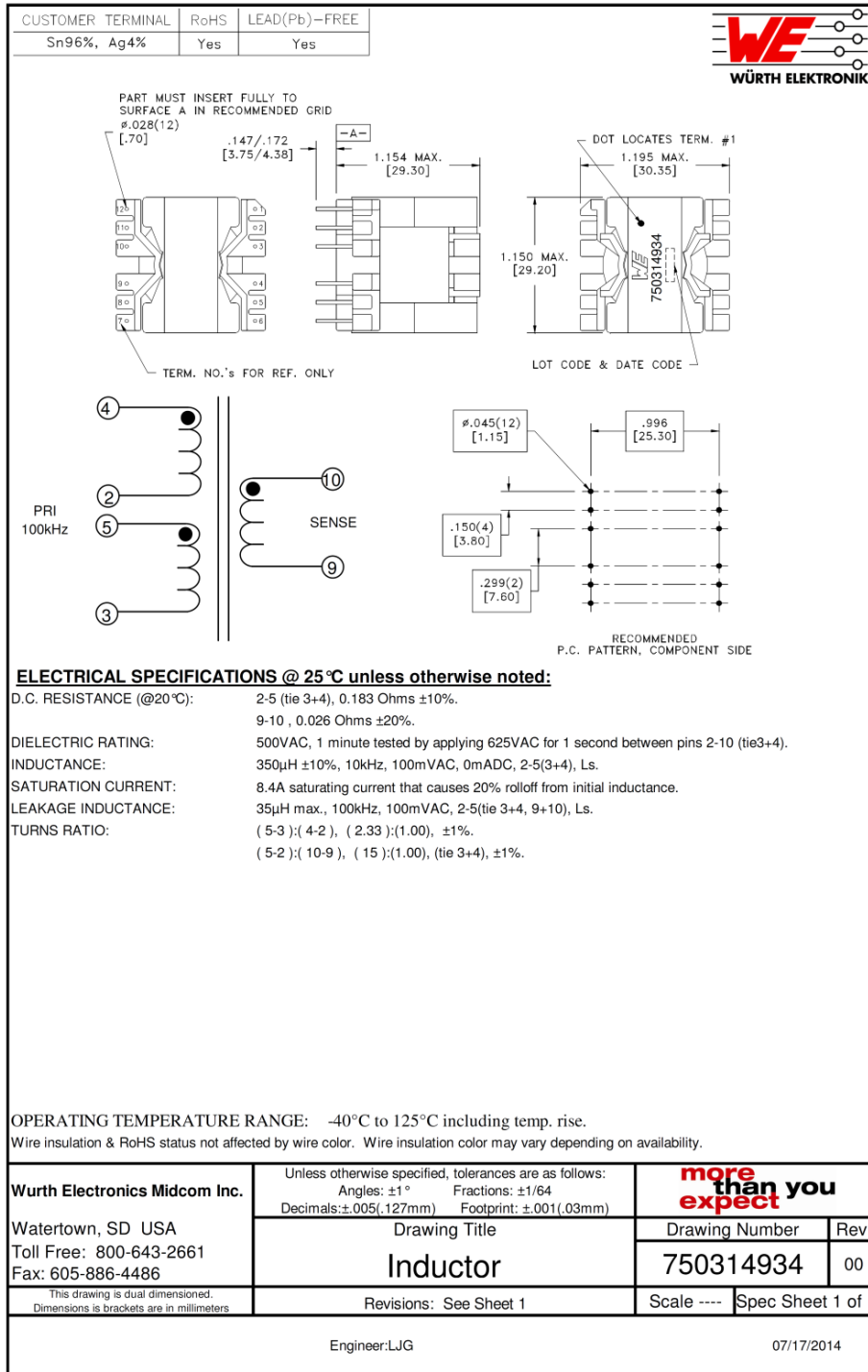
# NCL30030GEVB

## FLYBACK TRANSFORMER SPECIFICATION



# NCL30030GEVB

## PFC INDUCTOR SPECIFICATION



# NCL30030GEVB

## ECA PICTURES

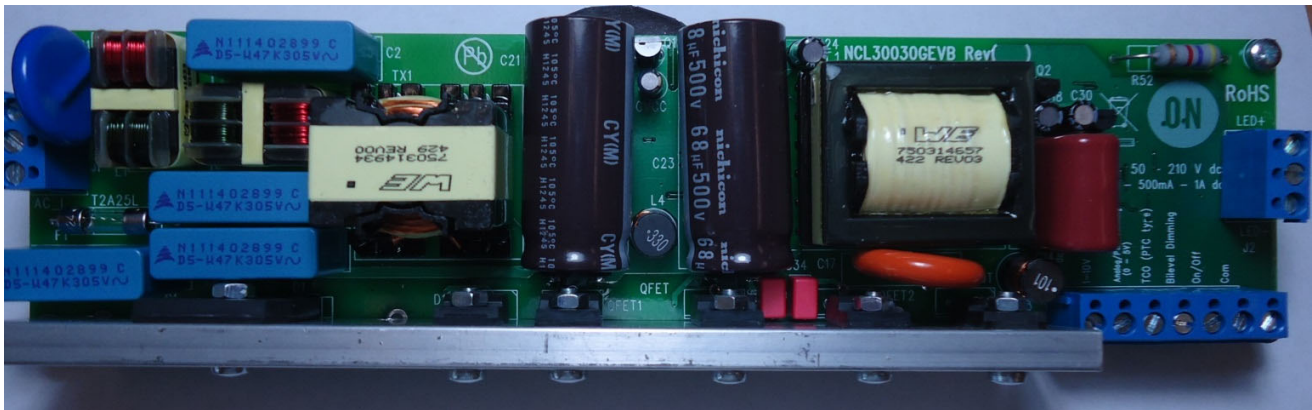


Figure 13. Top View

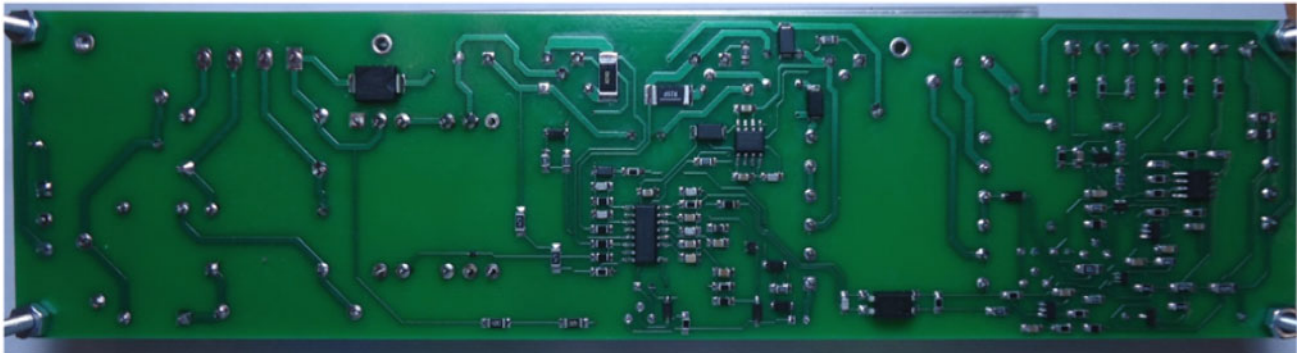


Figure 14. Bottom View

## NCL30030GEVB

Material - 6063/61 Al  
Break sharp edges

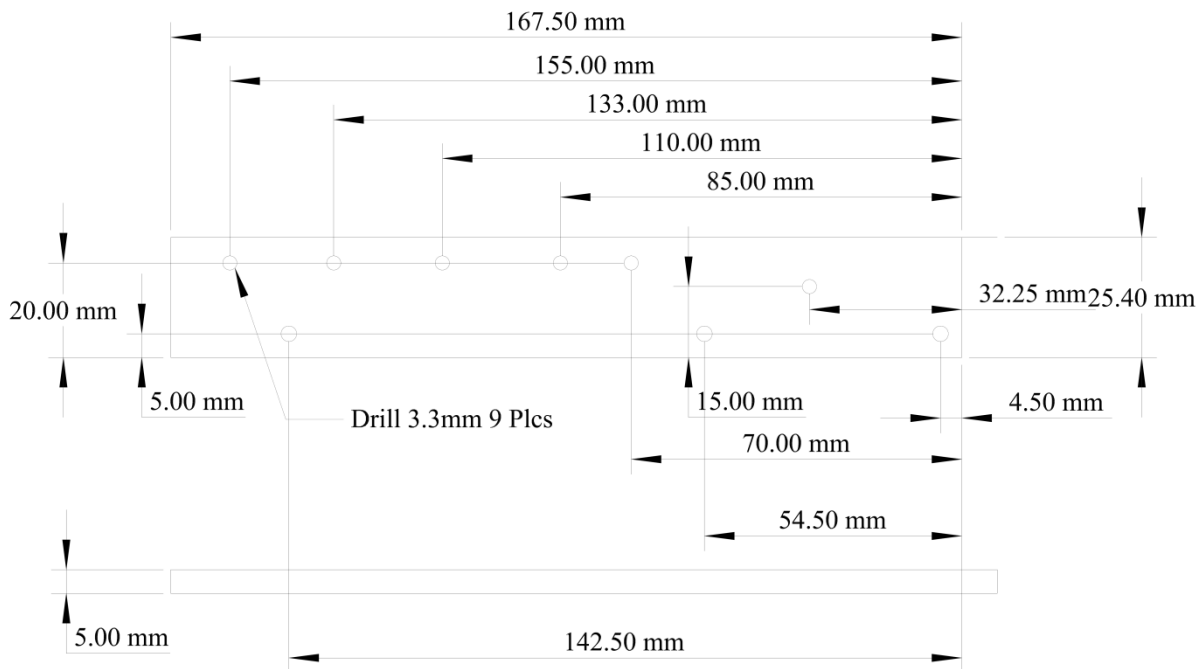


Figure 15. NCL30030 Heatspreader

### TEST PROCEDURE

#### Equipment Needed

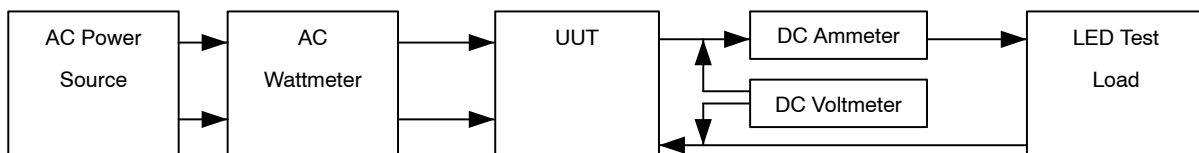
- AC Source – 90 to 305 V ac 50/60 Hz Minimum 500 W capability
- AC Wattmeter – 300 W Minimum, True RMS Input Voltage, Current, Power Factor, and THD 0.2% accuracy or better
- DC Voltmeter – 300 V dc minimum 0.1% accuracy or better
- DC Ammeter – 1 A dc minimum 0.1% accuracy or better
- LED Load – 50 V – 210 V @ 1 A

#### Test Connections

1. Connect the LED Load to J2 through the ammeter shown in Figure 16.

**WARNING:** Observe the correct polarity or the load may be damaged.

2. Connect the AC power card to J1 and connect the other end to the AC wattmeter shown in Figure 16.
3. Connect a Switch between J3–6 and J3–7. This switch will provide on/off control.
4. Short J3–4 to J3–7. This replaces the external TCO.
5. Connect a 100k Potentiometer to J3 as follows: high side to J3–1, wiper to J3–2, low side to J3–7.
6. Connect the DC voltmeter as shown in Figure 16.



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

Figure 16. Test Set Up

# NCL30030GEVB

## Functional Test Procedure

1. Set the potentiometer to about 50% of its rotation.

NOTE: The on-off switch should be in the open state until instructed otherwise.

2. Set the LED Load for 60 V output.

3. Set the input power to 120 V 60 Hz.

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

4. Close the On/off switch.

## LINE AND LOAD REGULATION

**Table 4. 120 V / MAX LOAD**

Set the potentiometer fully CW (i.e. maximum output)

|       | Output Current<br>710 mA $\pm$ 14 mA | Output Power | Power Factor | THD < 20% |
|-------|--------------------------------------|--------------|--------------|-----------|
| 60 V  |                                      |              |              |           |
| 120 V |                                      |              |              |           |
| 210 V |                                      |              |              |           |

**Table 5. 120 V / MIN LOAD**

Set the potentiometer fully CCW (i.e. minimum output)

|       | Output Current<br>70 mA Max | Output Power | Power Factor |  |
|-------|-----------------------------|--------------|--------------|--|
| 60 V  |                             |              |              |  |
| 120 V |                             |              |              |  |
| 210 V |                             |              |              |  |

**Table 6. 277 V / MAX LOAD**

Set the potentiometer fully CW (i.e. maximum output)

|       | Output Current<br>710 mA $\pm$ 14 mA | Output Power | Power Factor | THD < 20% |
|-------|--------------------------------------|--------------|--------------|-----------|
| 60 V  |                                      |              |              |           |
| 120 V |                                      |              |              |           |
| 210 V |                                      |              |              |           |

**Table 7. 277 V / MIN LOAD**

Set the potentiometer fully CCW (i.e. minimum output)

|       | Output Current<br>70 mA Max | Output Power | Power Factor |  |
|-------|-----------------------------|--------------|--------------|--|
| 60 V  |                             |              |              |  |
| 120 V |                             |              |              |  |
| 210 V |                             |              |              |  |

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

# NCL30030GEVB

## TEST DATA

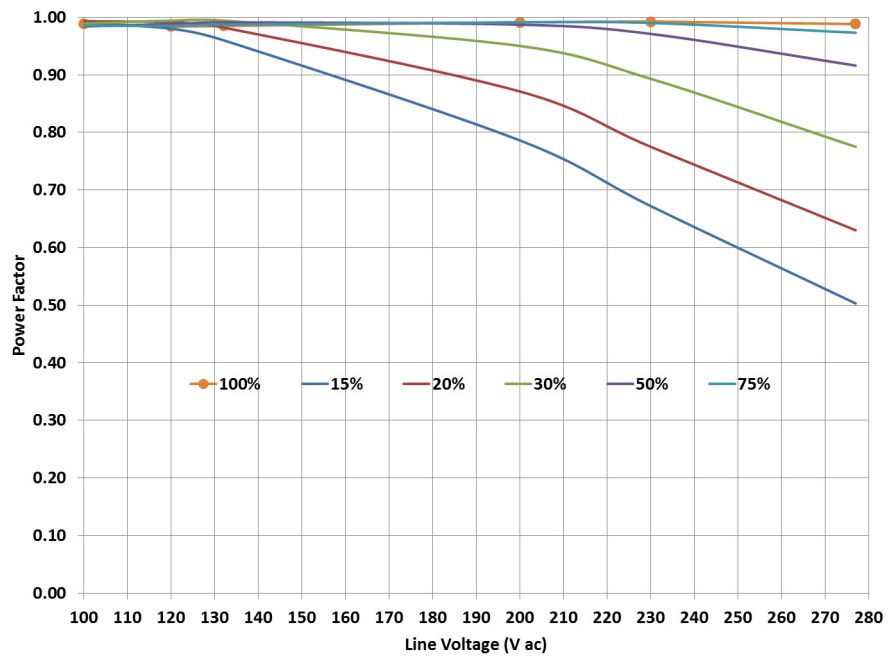


Figure 17. Power Factor over Line and Load

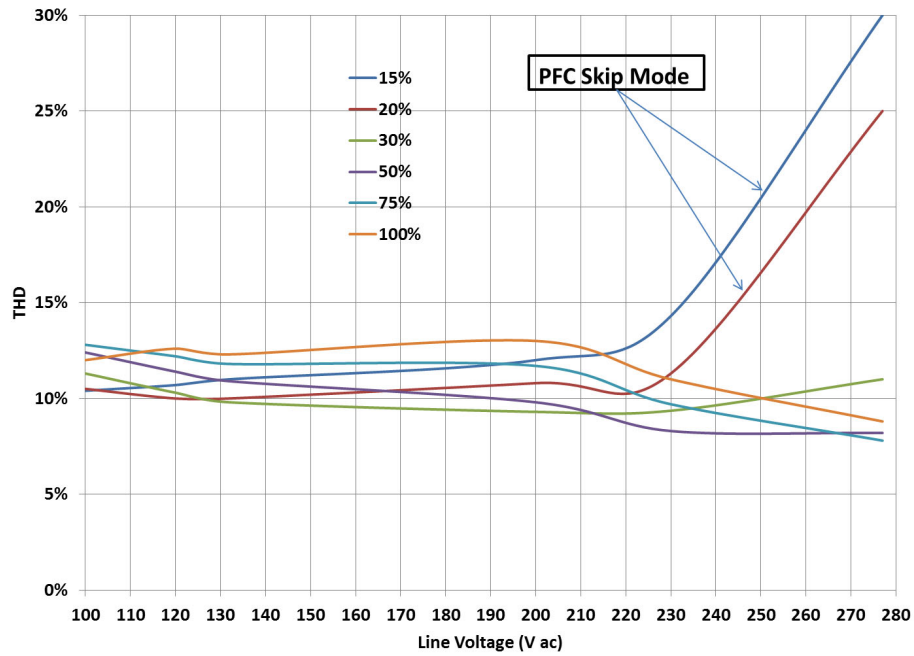


Figure 18. THD over Line and Load

# NCL30030GEVB

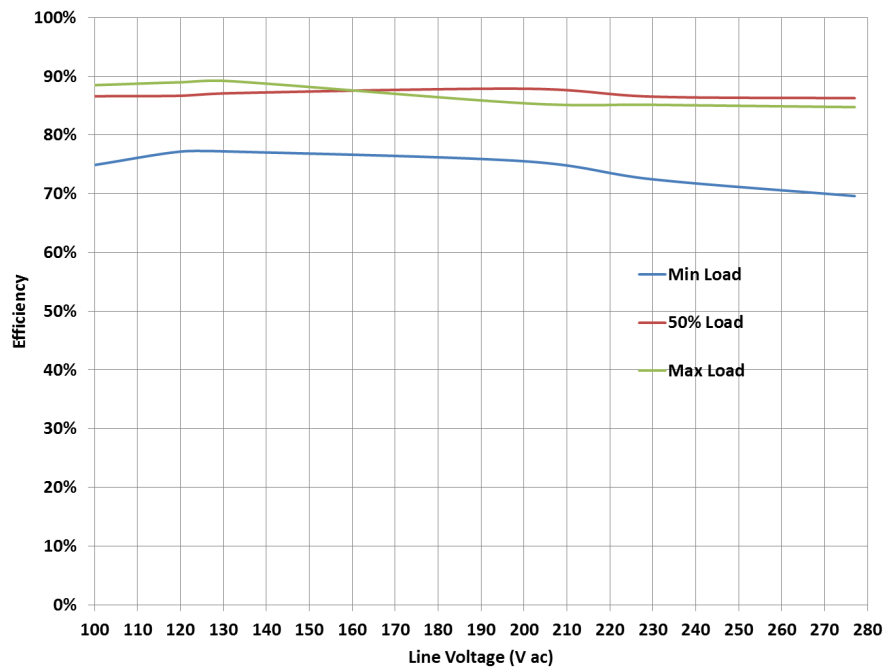


Figure 19. Efficiency over Line and Load @ 60 V dc Output

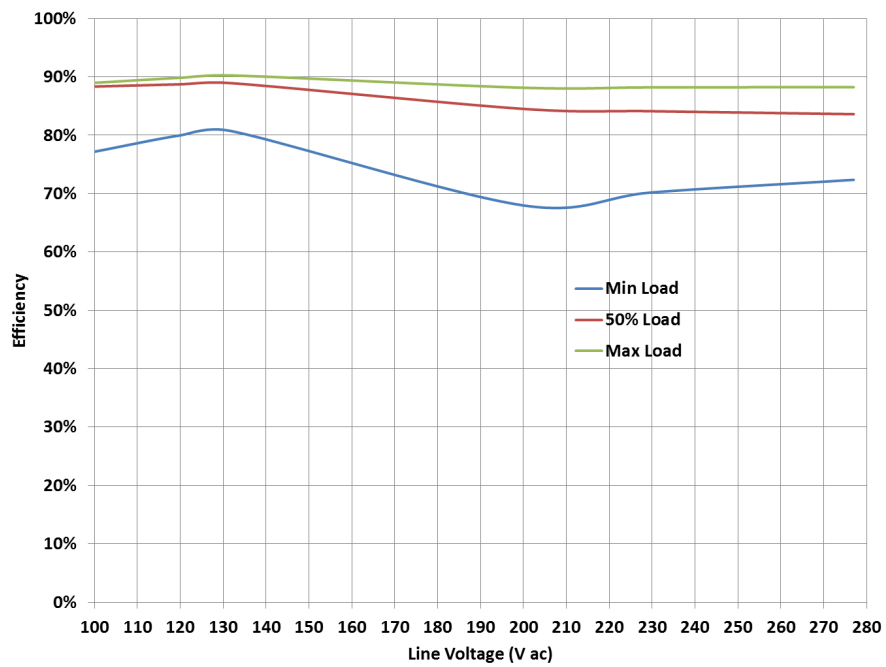


Figure 20. Efficiency over Line and Load @ 120 V dc Output

# NCL30030GEVB

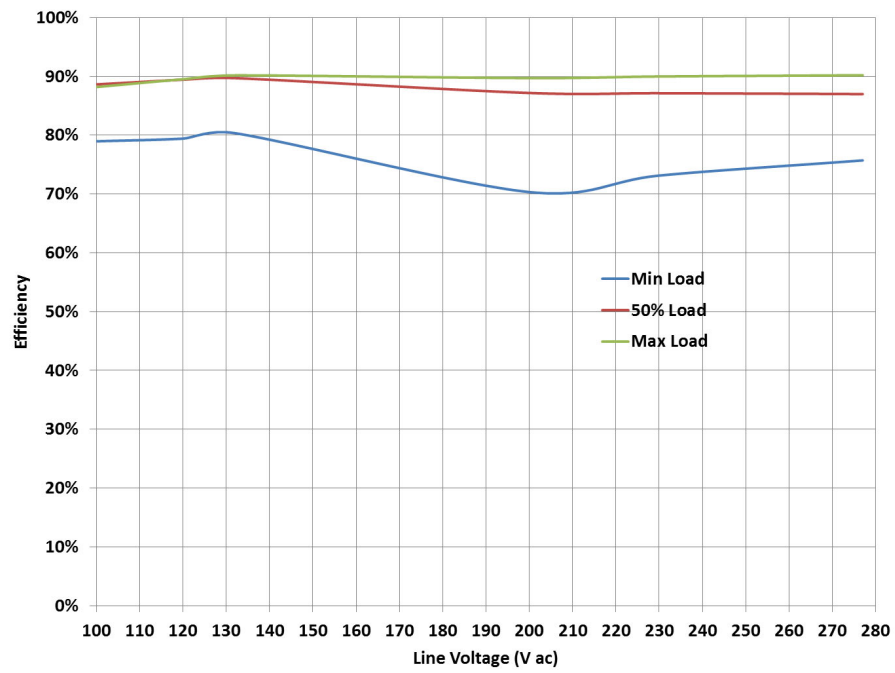


Figure 21. Efficiency over Line and Load @ 210 V dc Output

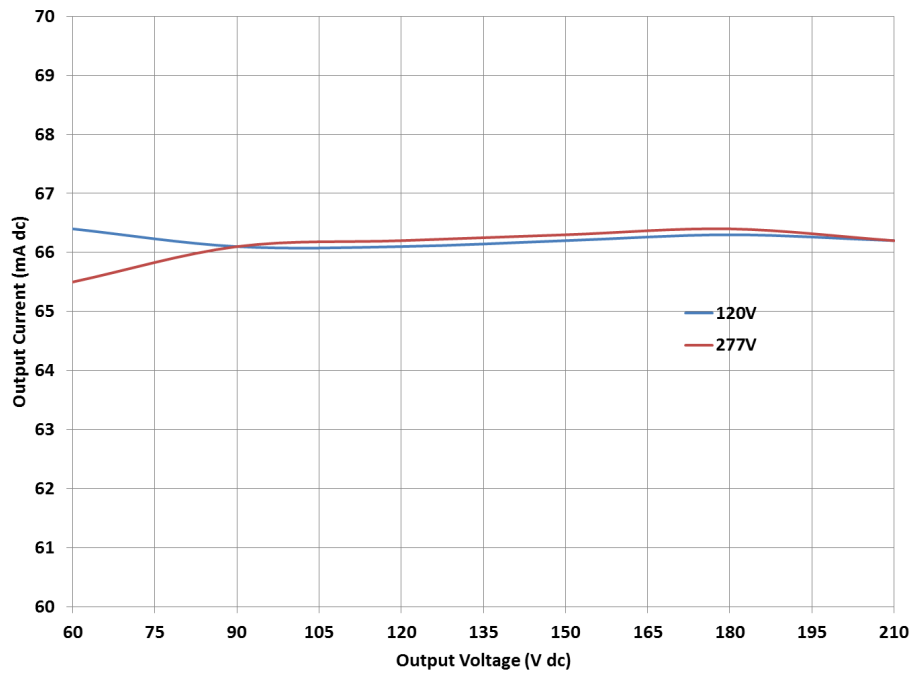


Figure 22. Minimum Load Regulation over Line

## NCL30030GEVB

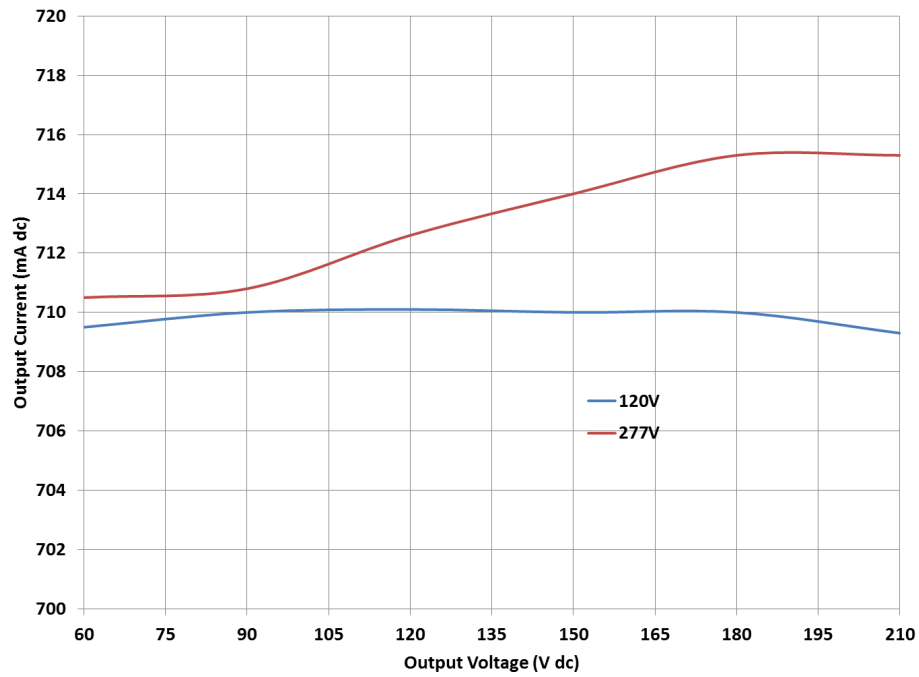


Figure 23. Maximum Load Regulation over Line

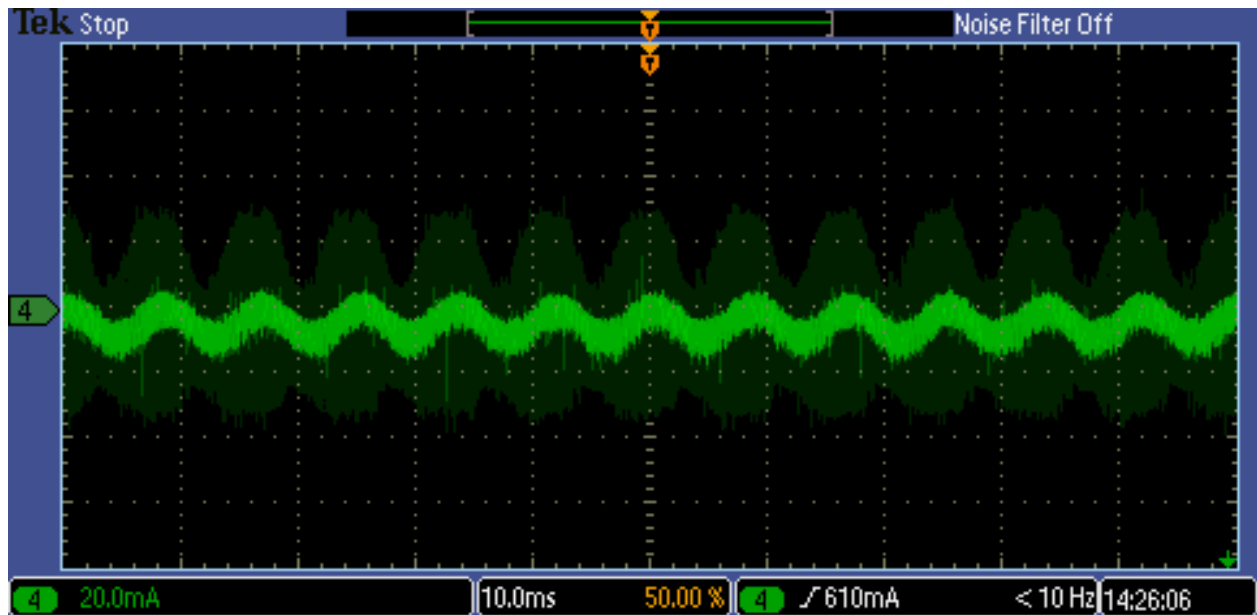


Figure 24. Ripple Current at 120 V ac Maximum Load

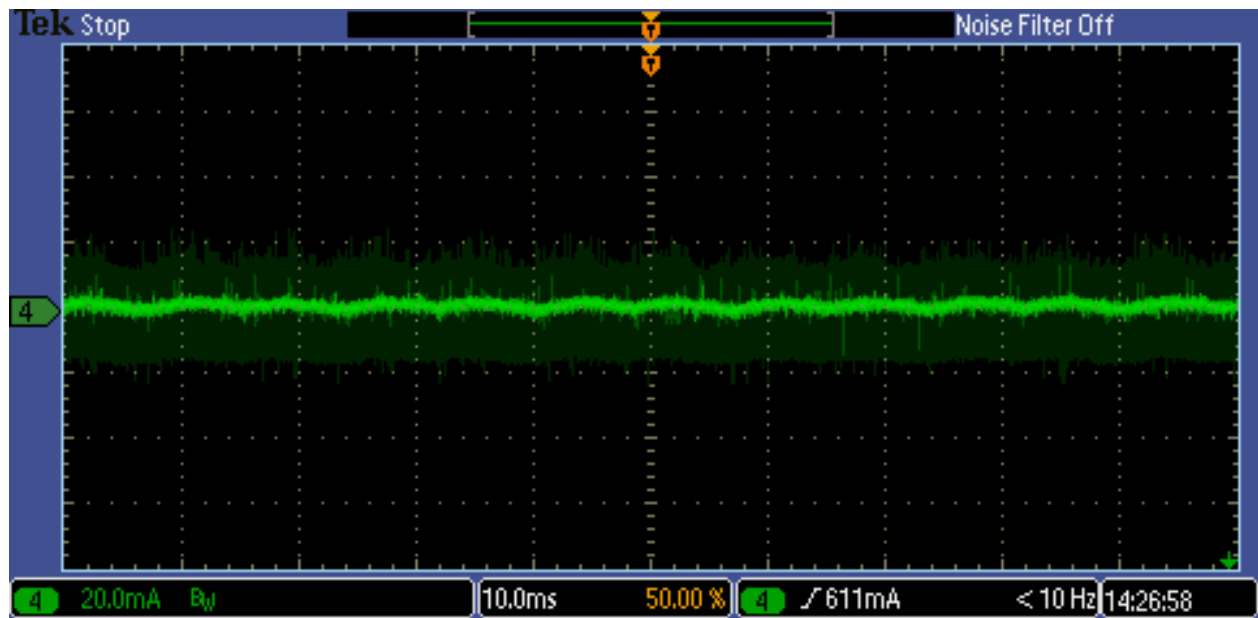


Figure 25. Ripple Current at 277 V ac Maximum Load

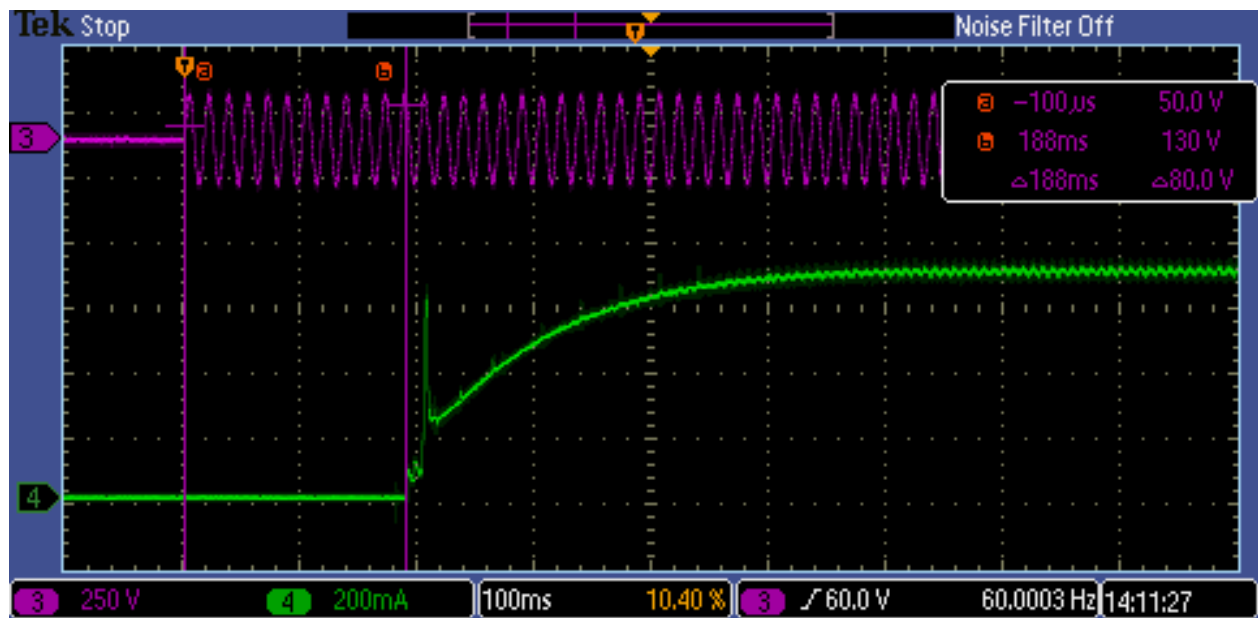


Figure 26. Start Up with AC Applied 120 V Maximum Load

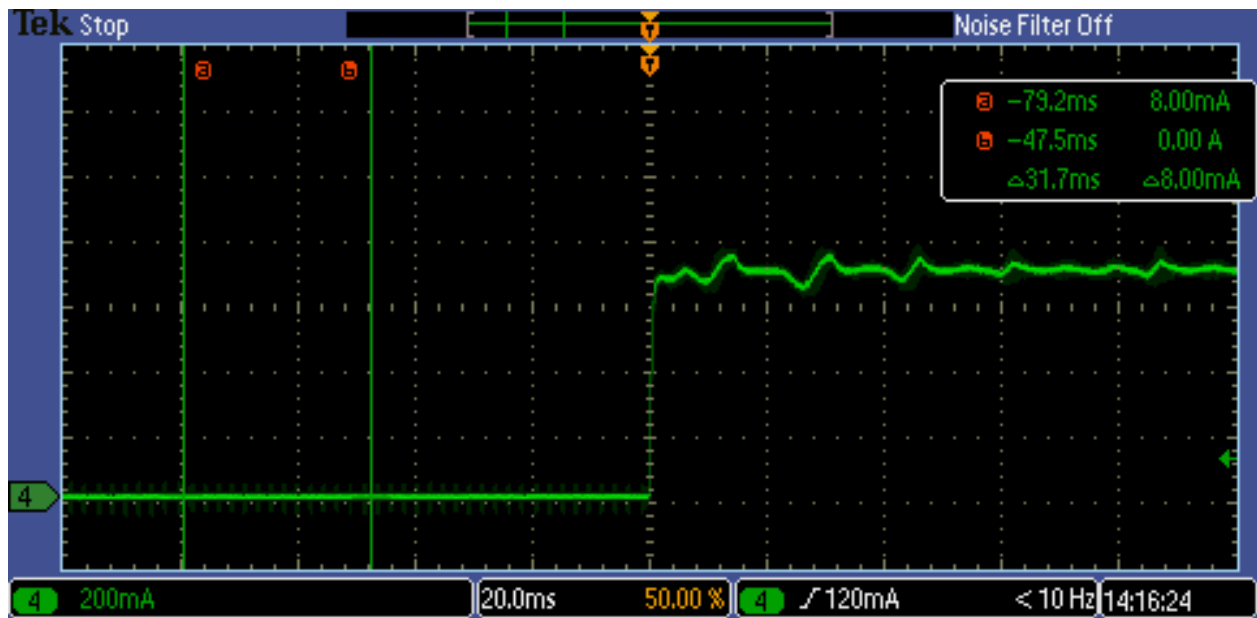


Figure 27. Start Up with On/Off 120 V Maximum Load

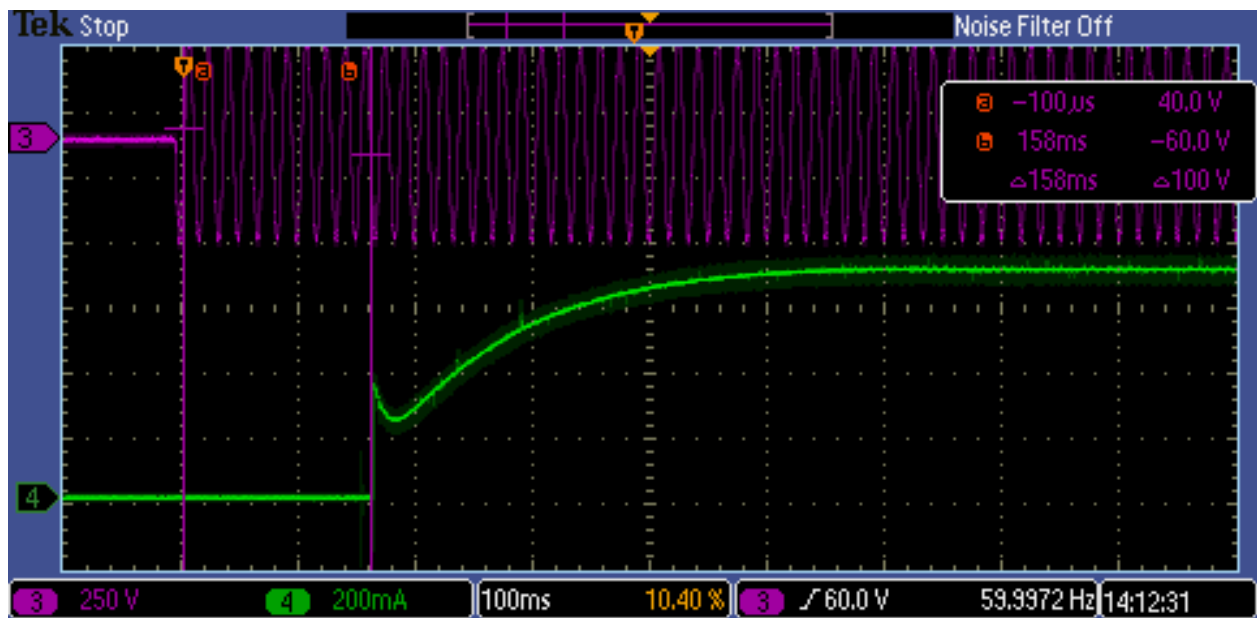


Figure 28. Start Up with AC Applied 277 V Maximum Load

# NCL30030GEVB

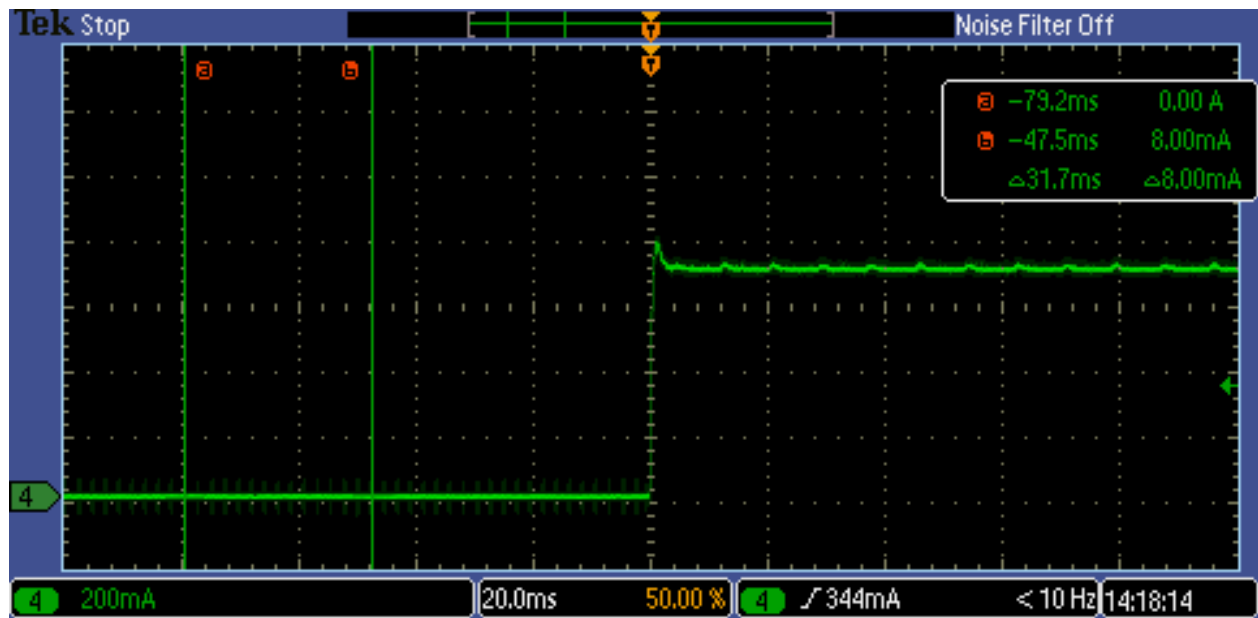


Figure 29. Start Up with AC Applied 277 V Maximum Load

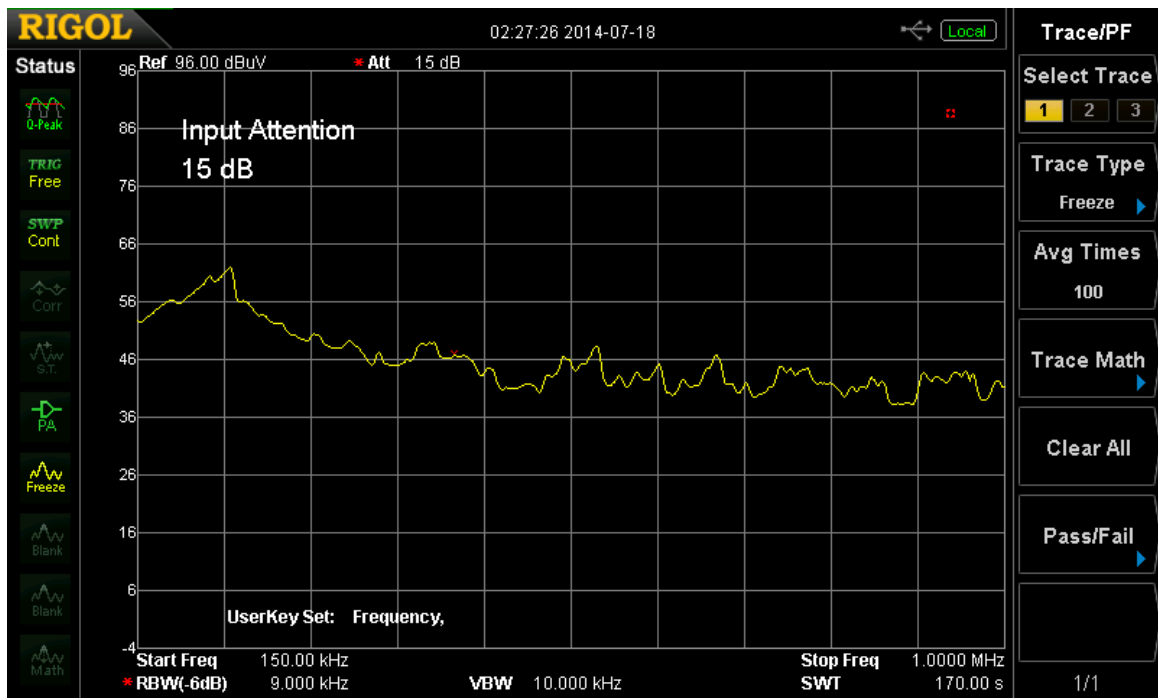
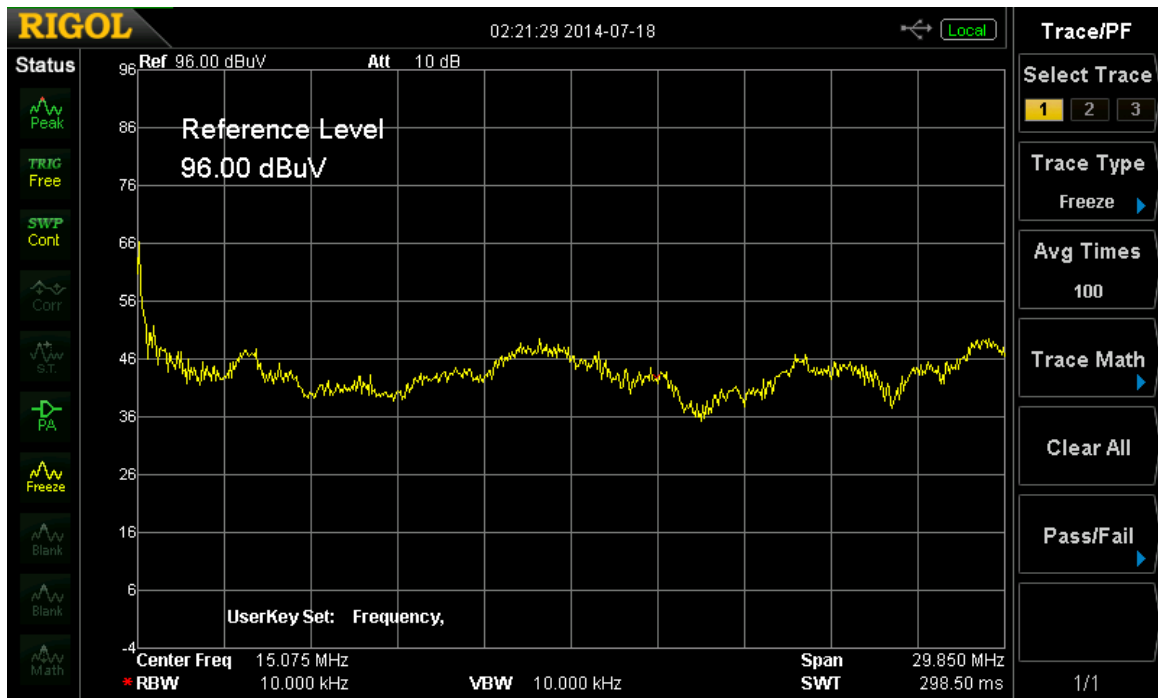


Figure 30. Conducted EMI Pre-compliance QP Data 150 kHz – 1 MHz



# NCL30030GEVB

|                                                                                                                                                                    |                            |                       |                            |                                             |                            |                |                  |                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-----------------------|----------------------------|---------------------------------------------|----------------------------|----------------|------------------|-----------------|
| <b>Product:</b> NCL30030_04                                                                                                                                        |                            | <b>Serial No.</b> N/A |                            | 18-Jul-2014 3:27:03PM                       |                            |                |                  |                 |
| <b>Description:</b> 277Vac 50% Load                                                                                                                                |                            |                       |                            | <b>Page:</b> 1 of 1                         |                            |                |                  |                 |
| <b>Voltech Pre-Compliance IEC61000-3-2 Windows Software</b>                                                                                                        |                            |                       |                            | <b>Test Date:</b> 18th Jul 2014 15:22:56 PM |                            |                |                  |                 |
| <b>Type of Test:</b> IEC61000-3-2:2005 with Interharmonics to EN61000-4-7:2002                                                                                     |                            |                       |                            | - Worst Case Table                          |                            |                |                  |                 |
| <b>Power Analyzer:</b> Voltech,PM1000+,100008202290,Ver.4.25                                                                                                       |                            |                       |                            | <b>AC Source:</b> Mains / AC Source         |                            |                |                  |                 |
| <b>Notes:</b>                                                                                                                                                      | <b>Overall Result</b> PASS |                       | <b>Class:</b> Class C,>25W |                                             | <b>Class Multiplier:</b> 1 |                |                  |                 |
| Supply Voltage outside permitted limits. Voltage Crest Factor outside permitted limits.                                                                            |                            |                       |                            |                                             |                            |                |                  |                 |
|                                                                                                                                                                    |                            |                       |                            |                                             |                            |                |                  |                 |
| <L1 : Reading is below limit 1.      <L2 : Reading is below limit 2.      *x: Where Class D test has failed mA/W.      <L2 (A) Reading is below 200% Class A Only. |                            |                       |                            |                                             |                            |                |                  |                 |
| N/A : Harmonic current below 0.6% of rated current or 5mA, whichever is greater Or where the test is not applicable.                                               |                            |                       |                            |                                             |                            |                |                  |                 |
| <b>Harm</b>                                                                                                                                                        | <b>Limit1</b>              | <b>Limit2</b>         | <b>Avg Rdg</b>             | <b>&lt;L1</b>                               | <b>&lt;L2</b>              | <b>Max Rdg</b> | <b>&lt;L2(A)</b> | <b>PassFail</b> |
| 2                                                                                                                                                                  | 8.03mA                     | 12.045mA              | 392.51uA                   | N/A                                         | N/A                        | 439.74uA       | N/A              | Pass            |
| 3                                                                                                                                                                  | 109.13mA                   | 163.70mA              | 35.320mA                   | ✓                                           | ✓                          | 35.413mA       | N/A              | Pass            |
| 4                                                                                                                                                                  | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 5                                                                                                                                                                  | 40.15mA                    | 60.225mA              | 5.8642mA                   | ✓                                           | ✓                          | 6.0307mA       | N/A              | Pass            |
| 6                                                                                                                                                                  | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 7                                                                                                                                                                  | 28.105mA                   | 42.157mA              | 2.8301mA                   | N/A                                         | N/A                        | 2.9105mA       | N/A              | Pass            |
| 8                                                                                                                                                                  | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 9                                                                                                                                                                  | 20.075mA                   | 30.112mA              | 4.4183mA                   | N/A                                         | N/A                        | 4.5284mA       | N/A              | Pass            |
| 10                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 11                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 4.2518mA                   | N/A                                         | N/A                        | 4.3112mA       | N/A              | Pass            |
| 12                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 13                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 4.4052mA                   | N/A                                         | N/A                        | 4.4703mA       | N/A              | Pass            |
| 14                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 15                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 5.2873mA                   | ✓                                           | ✓                          | 5.3438mA       | N/A              | Pass            |
| 16                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 17                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 6.2557mA                   | ✓                                           | ✓                          | 6.3697mA       | N/A              | Pass            |
| 18                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 19                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 6.9573mA                   | ✓                                           | ✓                          | 7.044mA        | N/A              | Pass            |
| 20                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 21                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 6.8674mA                   | ✓                                           | ✓                          | 6.9895mA       | N/A              | Pass            |
| 22                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 23                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 5.1907mA                   | ✓                                           | ✓                          | 5.2708mA       | N/A              | Pass            |
| 24                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 25                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 3.9413mA                   | N/A                                         | N/A                        | 4.0163mA       | N/A              | Pass            |
| 26                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 27                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 1.9888mA                   | N/A                                         | N/A                        | 2.0764mA       | N/A              | Pass            |
| 28                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 29                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 1.5153mA                   | N/A                                         | N/A                        | 1.5804mA       | N/A              | Pass            |
| 30                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 31                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 918.62uA                   | N/A                                         | N/A                        | 970.26uA       | N/A              | Pass            |
| 32                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 33                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 852.27uA                   | N/A                                         | N/A                        | 921.39uA       | N/A              | Pass            |
| 34                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 35                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 875.08uA                   | N/A                                         | N/A                        | 943.05uA       | N/A              | Pass            |
| 36                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 37                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 741.90uA                   | N/A                                         | N/A                        | 800.19uA       | N/A              | Pass            |
| 38                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |
| 39                                                                                                                                                                 | 12.045mA                   | 18.067mA              | 842.32uA                   | N/A                                         | N/A                        | 1.0056mA       | N/A              | Pass            |
| 40                                                                                                                                                                 | N/A                        | N/A                   | N/A                        | N/A                                         | N/A                        | N/A            | N/A              | N/A             |

Figure 32. IEC61000-3-2 Report 277 V 50% Load 60 Hz

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