



NLP250 Series

Application Note 183

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Medical 250W 12V Front-End



1. Introduction

This Application Note describes the features and functions of Artesyn Technologies' NLP250 series of high power density, ac-dc power supply. These open-frame, U-channel modules are targeted specifically at the communications, distributed power, industrial and medical markets. The NLP250 series power supplies have a footprint of 4 x 7 inches with a component height of 1.5 inches for use in 1U applications

This series of power supplies are high-frequency, low-cost, high-density, high-performance ac-dc power supplies designed to operate with universal line inputs (85-264 Vac) at a rated continuous output power of up to 175 W with natural convection cooling and 250 W with forced air cooling. The power supplies meet all major safety standards (UL, CSA and VDE) and are CE marked to LVD directives. They comply with the EMC directives (EN61000-4-2, 3, 4, 5), meet input harmonic current limits standards EN61000-3-2, as well as FCC/CISPR 22 (EN55022) Class B Conducted EMI limits and Class A Radiated EMI limits.

The modules are fully protected against overcurrent, overvoltage and overtemperature conditions. Standard features include remote ON/OFF and remote sense.

In addition, a high level of reliability has been designed into all models through extensive use of conservative derating criteria. Automated manufacturing methods, together with an extensive qualification program, ensure that all NLP250 converters are extremely reliable.

The series complies with standard environmental expectations including shock, vibration, humidity and thermal performance.

2. Models

The NLP250 power supply family comprises of 2 series.

- The -96Sxx series are designed for Information Technology (IT) and Industrial Sector applications and meet all the requirements of IECIEE 60950 safety expectations.
- The -99Sxx series are designed for Medical Sector applications and meet all the requirements of IECIEE 60601 safety expectations.

The NLP250 IT series comprises of 3 models as listed in Table 1.

Model	Input Voltage	Output Voltage	Output Current
NLP250R-96S12J	85-264 Vac	12 Vdc	21.0 A
NLP250R-96S24J	85-264 Vac	24 Vdc	10.5 A
NLP250R-96S48J	85-264 Vac	48 Vdc	5.25 A

Table 1 - NLP250 IT Models

The NLP250 Medical series comprises of 2 models as listed in Table 2.

Model	Input Voltage	Output Voltage	Output Current
NLP250N-99S12J	85-264 Vac	12 Vdc	21 A
NLP250N-99S24J	85-264 Vac	24 Vdc	10.5 A

Table 2 - NLP250 Medical Models

Note: Nomenclature reference:

'R' refers to models designed for parallel function applications.

'N' refers to models designed for single unit applications.

RoHS Compliance Ordering Information



The 'J' at the end of the part number indicates that the part is Pb-free (RoHS 6/6 compliant). TSE RoHS 5/6 (non Pb-free) compliant versions may be available on special request, please contact your local sales representative for details.

2.1 Features

- Universal input range (85-264 Vac) with EMI Filter and PFC
- 250 W on main channel with forced air
- Standby output of 5 V @ 1.0 A and 12 Vdc @ 0.3 A fan output
- Integrated Or-ing diode option
- Integrated control and monitoring features
- Active current sharing (parallel versions)
- Overcurrent protection
- Overvoltage and overtemperature protection
- Compliance to EN55022-B conducted noise standard
- Compact size: 4 x 7 x 1.5 inches
- Available RoHS compliant

3. General Description

3.1 Electrical Description

A block diagram of the NLP250 series is shown in Figure 1. Extremely high efficiency power conversion is achieved through the use of ZVS and ZCS techniques.

The power conversion is implemented using a voltage-mode controlled resonant topology. Power is transferred magnetically across the isolation barrier, via isolating power transformers. The regulated voltage on the output pins is governed by closed loop voltage feedback techniques.

A front end EMI filter is provided, so that conducted EMI levels will comply with FCC Part 15, Class B and EN55022 (CISPR 22 test method) Class B limits. There is a designated harmonic current correction (HCC) stage to ensure the product meets EN61000-3-2 harmonic content requirements. The main output voltage channel is controlled by variable frequency in the dc-dc converter. Extensive output filtering on the secondary side ensures that the unit meets excellent stated regulation and transient response.

The output is adjustable over a range $\pm 5\%$ of the nominal output voltage, using the on board TRIM potentiometer. The converter can be shut down via a remote ON/OFF input that is referenced to the secondary side. This input is compatible with popular logic devices. A 'positive' logic input is supplied as standard. On board 'negative' logic ON/OFF is catered for but needs to be enabled appropriately before use. Remote sense for automatic line drop compensation is also provided, allowing a maximum 0.2 Vdc drop compensation from no load to full load on customer output connection cables/wire runs.

The output is monitored for overvoltage conditions. The unit will shutdown at the overvoltage set-point and is latched until power cycling or reset is performed. The power supply is also protected against overtemperature conditions. If the converter is overloaded or the ambient temperature gets too high, the converter will shut down until the temperature falls below a minimum threshold, after which restart is automatic. The unit incorporates continuous short circuit protection, employing a hiccup (cyclic) mode of operation to reduce

average output power. Recovery is automatic upon removal of the short. Additionally a factory supplied option is available for the unit to be latched after short circuit. This feature maybe the preferred method of system protection.

Additional signaling includes an input power good and dc output voltage good and a load share signal (on the parallel NLP250 'R' versions only) that can be used to indicate % loading. Active current sharing allows for Paralleling and for true fault tolerant applications the optional Or-ring version can be provided under appropriate model nomenclature.

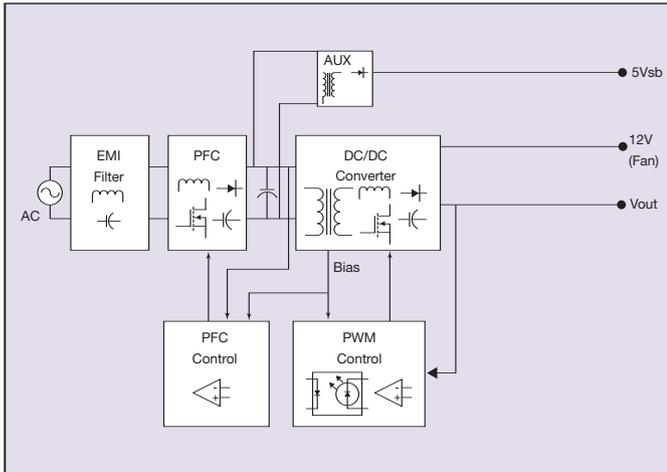


Figure 1 - Electrical Block Diagram

3.2 Mechanical Description

The NLP250 is constructed using a four-layer FR4 PCB. Both SMT and power components are placed on either side of the PCB. Heat dissipation of the power components is optimized, ensuring that control components are not thermally stressed. The standard supply is an open-frame U-channel product.

Figure 2 shows the mounting hole locations (metric and/or imperial) for horizontal (bottom/flat) assembly within applications. The unit also contains fixing hole locations on the side of the U-channel to allow for vertical (side) assembly as shown in Figure 3.

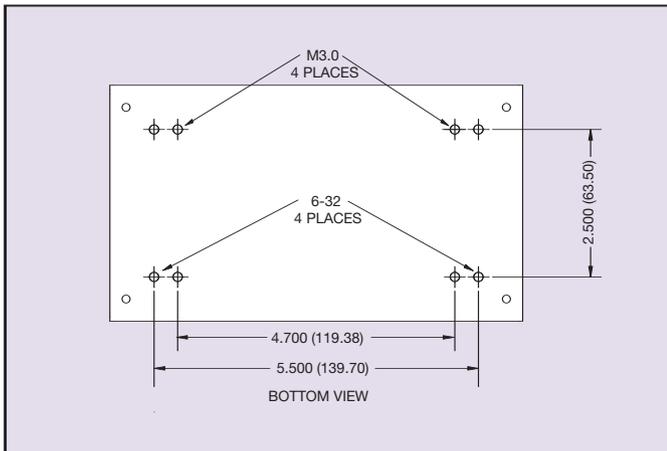


Figure 2 - Horizontal Mounting Hole Location Bottom View

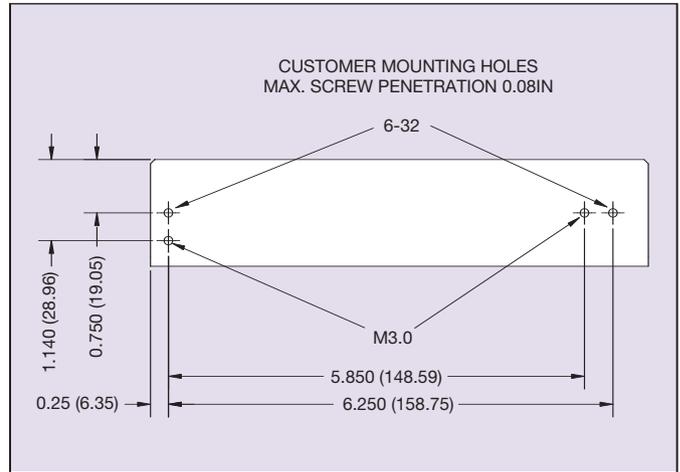


Figure 3 - Vertical Mounting Hole Location Side View

3.3 Connector Pin Assignment

A large diversity of connector housing and crimp terminals are available from many manufactures (e.g. housing with/without locking ramps, anti-vibrate crimps etc.). The molex suggestions below are therefore for reference purposes only, but should meet the requirements of most standard applications. It is advisory to consult with appropriate manufactures in order to best fit specific application needs.

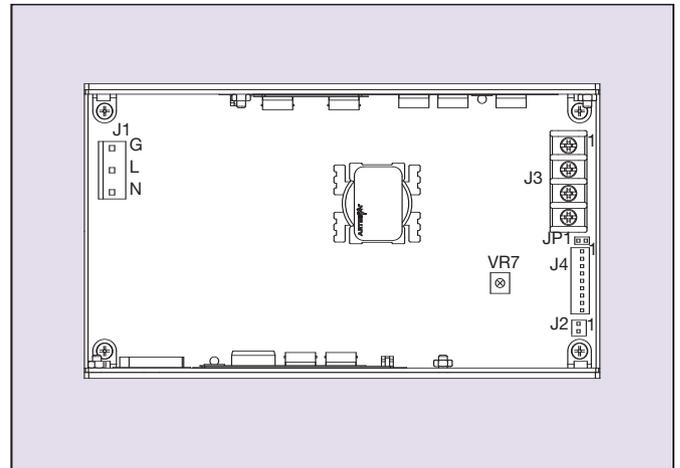


Figure 4 - Connector location J1/J2/J3/J4

CONNECTOR AND MATING CONNECTOR TYPES		
CONNECTOR	TYPE	MATING CONNECTOR
J1	Molex 09-65-2058 (5273 series) void pins 2 and 4 or equivalent	Molex 09-52-4054 (5239 series) or equivalent with Molex 08-52-0072 (2478 series) crimps or equivalent
J2	Molex 22-23-2021 (6373 series) or equivalent	Molex 22-01-3027 (2695 series) or equivalent with Molex 08-50-0113 (2759 series) crimps or equivalent
J3	Molex terminal block 387007504 or equivalent	N/A
J4	Molex 22-23-2091 (6373 series) or equivalent	Molex 22-01-3097 (2695 series) or equivalent with Molex 08-50-0113 (2759 series) crimps or equivalent

Table 3 - Connector Type and Mating Recommendations

- **J1** is the input connector, a standard 5-pin Molex type connector (Molex 5273 series) void of pins 2 and 4. The connector type and recommended mating connector (5239 series) and crimp terminals (2478 series) are listed in Table 3. The pin assignment is summarized in Table 4 and is assigned Left to Right as you face the connector.

J1 PIN CONNECTIONS	
Pin 1	Ground/Earth
Pin 2	Live
Pin 3	Neutral

Table 4 - J1 Pin Connections

Note: J1 - Pin 1 is provided for safety earth connection for units used in 3-wire applications. The metal U-Channel is internally connected to this pin.

- **J2** provides a 12 Vdc @ 300 mA external voltage. This may be used to run an external 12 Vdc fan in applications requiring additional cooling or airflow. The connector type (6373 series) and recommended mating connector (2695 series) and crimp terminals (2759 series) are listed in Table 3. The pin assignment is summarized in Table 5 and is assigned top to bottom.

J2 PIN CONNECTIONS		
Pin 1	+12 V	Fan Voltage
Pin 2	SGND	Return

Table 5 - J2 Pin Connections

Note: The unloaded voltage may be higher than the 12 Vdc advised.

- **J3** provides the main output voltage and is 6-32 screw terminal with clamp washer [at 0.325 in (8.3 mm) terminal pitch centres / 0.27 in (6.9 mm) wide]. Recommended wire sizes are 12-22 awg (0.5 to 2.5 mm²) and max tightening torque is 1.36 Nm (12 in.lb) The terminal assignment is summarized in Table 6 and is assigned right to left as you face the connector. Maximum output current allowed on each individual pin is 20 A.

J3 PIN CONNECTIONS		
Pin 1	Vo	+Main Output
Pin 2	Vo	+Main Output
Pin 3	RTN	Main Return
Pin 4	RTN	Main Return

Table 6 - J3 Pin Connections

- **J4** provides control signals. The connector type (6373 series) and recommended mating connector (2695 series) and crimp terminals (2759 series) are listed in Table 3. The pin assignment is summarized in Table 7 and is assigned right to left as you face the connector. See Section 5 for detailed description.

J4 PIN CONNECTIONS		
Pin 1	+S	+Vo Remote Sense
Pin 2	-S	-Vo Remote Sense
Pin 3	LS	Load Share Signal ('R' versions only)
Pin 4	PS OFF	Remote ON/OFF signal NO
Pin 5	PS ON	Remote ON/OFF signal NC
Pin 6	SGND	Signal Common
Pin 7	PW OK	Power Good
Pin 8	5 Vsb	Stand-by Voltage
Pin 9	DC OK	DC Power Good Signal

Table 7 - J4 Pin Connections

4. Performance Features and Functions

4.1 Electrical Input Characteristics

4.1.1 Input Voltage Range and EMC Expectation

All outputs will regulate within the specifications detailed in the shortform datasheet over an input voltage range of 85-264 Vrms and input frequency range of 47-63 Hz. In addition, dc input from 120-300 Vdc is also possible, although specifications may vary slightly.

Notes

- Mains input voltage dropouts or sags of any duration below the minimum specified above will not damage the supply and the unit will shut in a non-destructive and orderly manner. The supply will recover to normal operation when the ac line returns to within the specified range. Below a predetermined ac input voltage (approximately 80 Vac), the supply may shutdown. Restart and recovery to normal operation will be automatic and occur within 2 seconds after the input voltage returns to within the specified range. There is an inbuilt 5 Vac hysteresis to avoid intermittent hunting (spurious ON/OFF's).
- The units will withstand input fast transients specified in EN61000-4-4 Level 3 severity and input surges specified in EN61000-4-5 Level 3 severity. Transient or surges beyond these limits may damage the supply.
- The input harmonic currents comply with EN61000-3-2:1995 with Amendment A14:2000. The input power factor will be greater than 0.9 (90%) from 50% to 100% of rated load typically in the order of 0.95 or better.
- An internal EMI filter is provided, so that conducted EMI levels will comply with FCC Part 15, Class B and EN55022 (CISPR 22 test method) Class B limits.

4.1.2 Input Current

At 115 V 60 Hz input, the RMS input current shall be 3 A or less. Typical input currents at various line voltages are listed in Table 8.

Vin rms	Iin rms 250 W Series
85 V	3.92 A
120 V	2.78 A
230 V	1.36 A
264 V	1.16 A

Table 8 - Input RMS Current

Note - Model label marking is governed by appropriate safety approval certification and guidelines and thus may not reflect maximum operating conditions as advised on the technical datasheets.

4.1.3 Startup Surge (Inrush) Current

The peak cold start-up surge current at various line voltages are less than the values specified in Table 9.

Vin ac (rms)	Iin (peak, cold start)	Line Impedance (Ω)
85 V	14 A	0
120 V	18 A	0
230 V	35 A	0
264 V	40 A	0

Table 9 - Input Current (Worst Case)

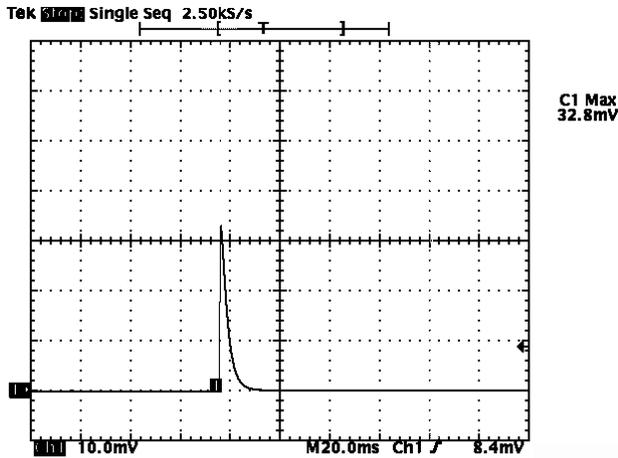


Figure 5 - Typical Surge Current @ 264 Vac (5 A/div) for 48 V Model

4.1.4 Input Fusing

- IT Sector Models (-96SxxJ)
The unit is equipped with an internal non user serviceable 6.3 A High Rupturing Capacity (HRC) 250 Vac fuse to IEC 127 for fault protection in the 'live' line input.
- Medical Sector Models (-99SxxJ)
The unit is equipped with an internal non user serviceable 6.3 A High Rupturing Capacity (HRC) 250 Vac fuse to IEC 127 for fault protection in both the 'live' and 'neutral' lines input.

4.2 Electrical Output Characteristics

Model number listing and output voltage and current ratings are specified on the relevant shortform datasheet.

Notes

- Voltages are factory settings, and the main output is adjustable $\pm 5\%$. (See Section 8.2).
- Maximum currents and power must not be exceeded.
- There is no minimum load requirement for any output.

4.2.1 Output Voltage Initial Accuracy and Trimming

All outputs have an initial setting accuracy better than $\pm 1\%$ at 75% of maximum rated load.

4.2.2 Regulation

The total output regulation for both line and load variations is better than $\pm 2\%$ of nominal voltage for all outputs.

4.2.3 Temperature Stability and Coefficient

The temperature coefficient of any output voltage is less than $\pm 0.02\%/^{\circ}\text{C}$, for the full Operating Temperature range of 0°C to 70°C .

4.2.4 Minimum Output Current

There are no minimum load requirements to maintain stated datasheet regulation. The NLP250 family is designed to cater for no load operation.

4.2.5 Output Current Surge Capability

The output current shall be capable of surging to 120% of maximum steady-state rated output current for no more than 500 ms. During the surge period, the output may not maintain the regulation limits. Please consult the factory for higher surge requirements.

4.2.6 Ripple and Noise

The peak-to-peak ripple and noise for all outputs is less than 1% of the nominal output voltage, over an ambient range of 0°C to 50°C .

(see Section 8.12 for more details).

4.2.7 Transient Response

For all main outputs, the maximum transient deviation for a step load change of 50% of maximum rated current is less than 5%. The maximum slew rate of load current is $0.5\text{ A}/\mu\text{s}$, and transient loads are applied to one output at a time. A minimum capacitor equal to $100\ \mu\text{F}/\text{A}$ of rated load current should be connected to the load point for appropriate measurement. Minimum output running current of 1 A is required for transient load examination.

The output will recover to within the regulation band within 1ms.

4.2.8 Hold-up Time

All outputs will remain within the specified regulation band for a period of at least 20 ms following a sudden loss of ac input voltage. The supply can be operated at full load, and the ac line power should be programmed to vanish at the zero crossing point.

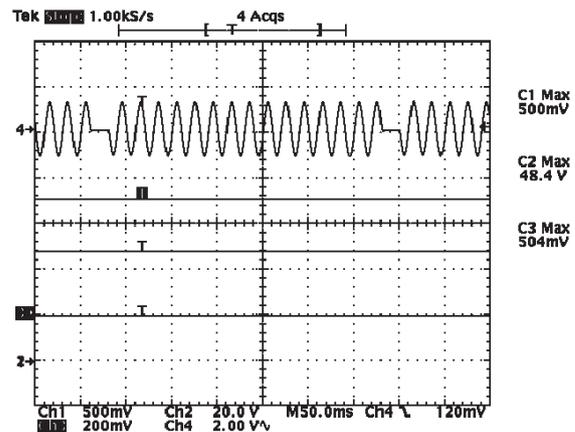


Figure 6 - Typical Hold-up Plot 48 V Model Full Load @ 85 Vac (Channel 1: PWOK; Channel 2: 48 V; Channel 3: DCOK; Channel 4: Mains)

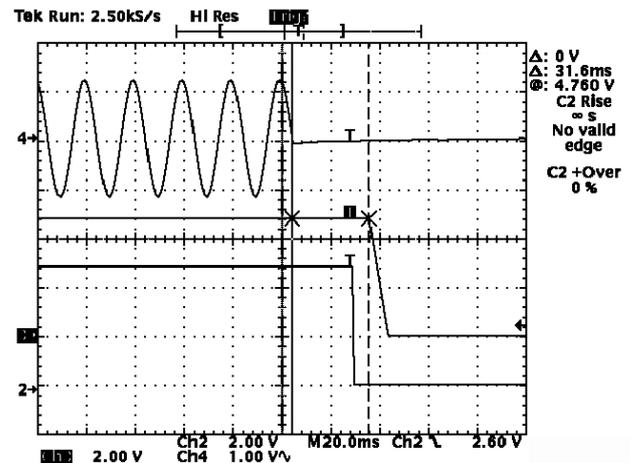


Figure 7 - Typical Hold-up Plot to Decay @ Full Load (Channel 2: PWOK; Channel 3: 48 V Decay; Channel 4: Mains)

Notes

- Hold-up time is mainly influenced by amount of loading and is shortest on full load.
- Testing indicates that the units will handle 50% input voltage dips for 500 ms at full load without interruption on output voltage supply.

4.2.9 Efficiency

The efficiency of the NLP250 series at worst case operating conditions at full rated load is greater than 80% and typically in the order of 83% for normal operating conditions. Efficiency may be as high as 88% depending on model and test configuration.

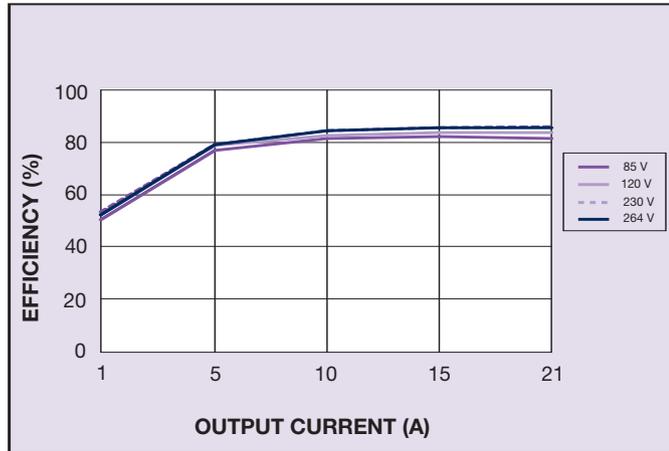


Figure 8 - Efficiency for NLP250R-96S12

4.2.10 Output Voltage Rise Time

The output voltage rise time (10% to 90% of V_{out}) will depend on model type, mains input voltage and amount of loading. Specification is for min. 5 ms \leq 200 ms for all possible variations and is typically 100 ms for 230 Vac.

Output voltage rise time is not influenced by method of turn-on (i.e. via mains only or via PS OFF/PS ON control signals).

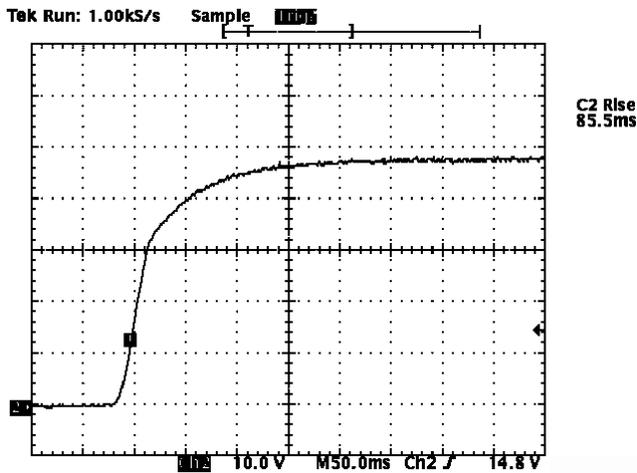


Figure 9 - Output Voltage Rise Time (48 V Model)

4.2.11 PSU Turn-on Time

The maximum delay from application of mains input voltage until the unit produces a valid output is less than 2 seconds worst case. Turn-on time is influenced by model type, main input voltage and method of turn-on (see Section 8.3 for more details).

4.3 Protection Features

4.3.1 Overload Protection

The NLP250 family includes internal current limit and power limit circuitry to prevent damage in the event of overload or short circuit. In the event of overloads, the output voltage may deviate from the regulation band but recovery is automatic when the load is reduced to within specified limits.

The NLP250 unit includes 2 types of current protection control, each set at different thresholds.

The first current sensing circuit (overload monitor) is set to 115% ($\pm 5\%$) of full load current. If an overload occurs this circuit takes control of the feedback loop and forces the unit into constant current mode. The unit delivers 115% of rated current, but its output voltage is reduced to maintain safe power dissipation. If the overload is removed the power supply will immediately revert to constant voltage control and resume regulation at voltage setpoint. If the overload persists for longer than 0.5 seconds or the output voltage goes below 10%, the second current sensing control (short-circuit monitor) is triggered, disabling the switching circuit and resetting the soft start. Effectively the unit enters hiccup mode of operation, whereby the output will shut down and automatically restart after a short delay (See Figure 10).

Notes

- The overload monitor 0.5 second delay is a useful feature for applications that require large peak current demands during start-up and normal running conditions.
- The short-circuit monitor (hiccup mode) provides appropriate pulse current that maybe used to blow discriminating fuses within the application PCB.

4.3.2 Short-circuit Protection

All outputs are protected against continuous short-circuit. The outputs protect themselves against short-circuit failure (defined as output impedance less than or equal to 0.1 Ω) for an indefinite period of time by cyclic operation (hiccup). Latched up protection can be chosen as a factory supplied option. The inception point is typically 120% of rated full load for all models. The hiccup current limit scheme has many advantages, including increased capacitive load start-up capability (See Section 8.7). Outputs will automatically resume normal operation when the fault is removed.

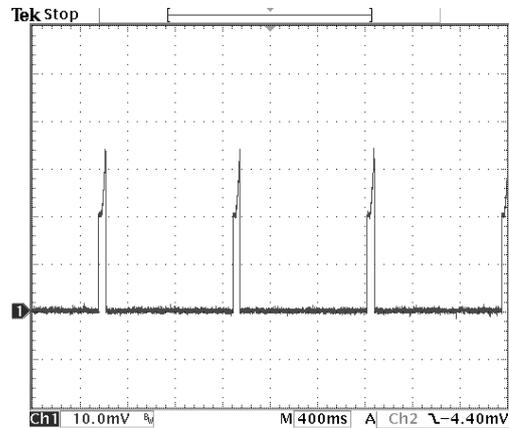


Figure 10 - Short Circuit - Hiccup Mode 10 A/div (12 V model)

Notes

- For extended overloads or short circuits, the power supply may enter a hiccup mode to limit average output power or thermal protection may shutdown and lock out the supply. In the event of thermal shutdown, recovery is automatic when normal operating temperatures are restored.
- None of the module specifications are guaranteed when the unit is operated in an overcurrent condition. The unit will not be damaged in an overcurrent condition because it will be protected by the OTP function, but the converter's lifetime may be reduced.
- The 5 Vsb will remain active during overload or short circuit on the main output.

4.3.3 Output Overvoltage Protection

All NLP250 models include OVP protection for the output. The power supply OVP shutdown circuit shall be activated when any output voltage exceeds $115\% \pm 5\%$ of nominal value. When the OVP is activated, the output is shutdown and the power supply will lock out until the ac power is cycled or the remote ON/OFF is asserted for 1 second (i.e. PS OFF signal is pulled low or PS ON signal is pulled high). During lockout, the 5 Vsb output will remain active as long as the input voltage is always above the low ac shutdown threshold. Note: Output under voltage protection is not provided.

4.3.4 Over-Temperature Protection (OTP)

The NLP250 is equipped with non-latching overtemperature protection. A temperature sensor monitors the temperature of the PFC power MosFet and output ORing device (if fitted). If the temperature exceeds a threshold of 125 °C (typical) the power supply will shut down, disabling the output. When the FET substrate temperature has decreased to between 90 °C and 100 °C the converter will automatically restart.

The NLP250 might experience overtemperature conditions during a persistent overload on the output. Overload conditions can be caused by external faults. OTP might also be entered due to a loss of control of the environmental conditions e.g. an increase in the converter's ambient temperature due to a failing fan or external cooling system etc.

During thermal shutdown, the 5 Vsb output will remain active as long as the input voltage remains above the low ac shutdown threshold.

4.4 Environmental Features

4.4.1 Operating Temperature

The power supplies will start and operate within stated specifications at an ambient temperature from 0 °C to 50 °C under all load conditions. Derate output current and power by 2.5% per °C above 50 °C. Maximum operating ambient temperature is 70 °C (which implies a 50% derating at max 70 °C ambient).

4.4.2 Storage and Shipping Temperature/Humidity

The power supplies can be stored or shipped at temperatures between -40 °C to +85 °C and relative humidity from 5-95% non-condensing.

4.4.3 Altitude

The power supplies will operate within specifications at altitudes up to 10,000 feet. The power supply will not be damaged when stored in altitudes up to 30,000 feet. Operation in some environments may require derating (See Section 8.8 for optimum thermal performance guidelines)

4.4.4 Humidity

The power supplies will operate within specifications when subjected to a relative humidity from 5% to 90% non-condensing.

4.4.5 Shock

The power supplies will pass shock test of 30 Grms, half sine, 11 msec, allowing for one drop on each of the six faces.

4.4.6 Vibration

The power supplies, while not operating, will withstand random vibrations in 3 orthogonal axes, 2.4 Grms, 5-500 Hz for 10 minutes each axis.

4.4.7 Electrostatic Discharge (ESD)

The power supplies will pass ESD tests of EN61000-4-2 standards, level 3 severity with normal performance (NR).

4.4.8 Electromagnetic Susceptibility

The power supplies shall perform satisfactorily when subjected to radiated electromagnetic interference per EN61000-4-3 standards, level 3 severity with normal performance (NR).

5. Monitoring and Signal Interfacing

5.1 Remote Shutdown/Remote ON/OFF (PS OFF and PS ON)

The NLP250 series includes normally open (NO) remote shutdown or inhibit PS OFF as standard. If the PS OFF signal is asserted low, the supply will shut down within 200 ms. When PS OFF is high or open, the power supply will start and run normally. The open circuit voltage at PS OFF is a logic high (+5 Vdc).

The NLP250 series also includes a closed (NC) remote shutdown/inhibit control PS ON as standard. Units are factory set with PS ON disabled by a connection to common (Jumper JP1 inserted). With the factory connection JP1 removed, the power supply is normally inhibited. If PS ON is asserted low, the supply will start and run normally, and when PS ON is opened, the supply will shutdown within 200 ms. The open circuit voltage at PS ON is a logic high.

Note: When using PS ON, the PS OFF pin should be left open circuit. Activating the remote shutdown inhibits the output voltage and 12 Vdc fan supply. The 5 Vsb remains active. Both signals are TTL/CMOM compatible input signal (see Section 8.4 for more details).

5.2 Remote Sensing (+S, -S)

Remote sensing (+S, -S) is provided for all output ratings. The remote sense circuitry will overcome a total voltage drop of 0.2 V between the output terminals and the remote sense point (See Section 8.7 for more details).

5.3 Output Good (DC OK)

The NLP250 series includes a DC OK signal. When the output voltage is within 8% of nominal (i.e. $V_o > -8\%$ of the nominal), the DC OK signal will switch to a logic high (5 V), and can source 5 mA or less. If the ac input voltage is below limits to maintain regulation of the outputs, or if a protective shutdown circuit operates, DC OK will switch to a logic low. DC OK is an TTL compatible output signal (see Section 8.6 for more details).

5.4 Power Good (PW OK)

The NLP250 series includes a PW OK signal. When the power supply starts, this signal will switch to a logic high within 500 ms. When the ac input is interrupted, the PW OK signal will switch to a logic low at least 5 ms before loss of output regulation. PW OK is an TTL compatible output signal (see Section 8.5 for more details).

5.5 Standby Voltage (5 Vsb)

In addition to the main outputs, all NLP250 models are equipped with a 5 V stand-by output (5 Vsb) for use with supervision and control. The 5 Vsb output remains active when the power supply is limited or shut down by control or protective circuitry. Low input voltage shutdown will also shutdown the 5 Vsb. Maximum current for the 5 Vsb output is 1.0 A and regulation is $\pm 5\%$. The 5 Vsb return should be SGND (J4 pin 6) or the main output ground (J3 pins 3 or 4).

5.6 Load Share (LS) - 'R' versions only

When operating the NLP250 'R' versions alone within single module applications, the J4 pin # 3 LS signal may be used to measure output current where $4.8 \text{ V} \pm 10\%$ equals 100% load and is linear in design. Thus 50% load will equate to $2.4 \text{ V} \pm 10\%$ Otherwise the signal is used to parallel multiple module systems (see Section 8.9 for more details).

5.7 Signal Common (SGND)

0 Vdc pin for return connection of control signals. This is the secondary ground of the PSU and is internally connected to the main output ground (0 Vdc) on J3 pins 3 and 4.

5.8 Fan Voltage (12 V Fan)

J2 (pin 1 = +12 V : pin 2 = SGND) provides an extra 12 Vdc signal designed to drive an external dc fan. The signal is rated for 0.3 A continuous rated operation. The fan output is not available when the main output is overloaded/current limited or shutdown by control or protective circuitry. Additionally the 12 V fan is independently short-circuit protected at approximately 0.9 A so that the main output will remain unaffected if fan failure/short occurs. Note: the PSU is independently protected for loss of system airflow.

During Artesyn thermal evaluation a 40 x 40 mm 12 Vdc fan (ref.: Delta P/N FFB0412VHN-F00) was used to check cooling effectiveness of the PSU at full loading.

6. Safety

6.1 Certification

The NLP250 power supply is intended for inclusion in other equipment and the installer must ensure that it is in compliance with all the requirements of the end application. This product is only for inclusion by professional installers within other equipment and must not be operated as a stand alone product.

The NLP250 (IT) series has been designed in accordance with EN 60950-1 and UL/cUL 60950-1 'Safety of Information Technology Equipment'. The series also conforms with the provisions of the European Council Low Voltage Directive 73/23/EEC (as amended by 93/68/EEC) to bear the CE Mark.

The NLP250 (Medical) series has been designed in accordance with EN 60601-1 and UL/cUL 60601-1 'Safety of Medical Equipment'

Note appropriate safety certificates and approvals are available to download from our website www.artesyn.com

6.2 Isolation

The galvanic isolation is verified in an electric strength test during production. The NLP250 (IT) series the test voltage between input and output is 3.0 k Vac and 1.5 k Vac between input to chassis. The NLP250 (Medical) series the test voltage between input and output is 4.0 k Vac and 1.5 k Vac between input to chassis. Also, note that the flammability ratings of the PCB and terminal support header blocks and all internal plastic constructions meet UL94V-0.

6.3 Input Fusing

The unit is equipped with an internal non user serviceable 6.3 A high rupturing capacity (HRC) 250 Vac fuse to IEC 127 for fault protection in the 'Live and/or neutral' line input depending on model type.

WARNING: FOR CONTINUED PROTECTION AGAINST FIRE, REPLACE ONLY WITH SAME TYPE AND RATING OF FUSE.

Notes

- CAUTION: Allow a minimum of 1 minute after disconnecting line power when making measurements or handling the Unit.
- The NLP250 family is NOT evaluated for use as critical components in life support equipment or use in hazardous or nuclear environments. If uncertain consult Artesyn Technologies.
- HIGH VOLTAGE WARNING: during operation dangerous voltages maybe present. These products maybe supplied open frame or

with covers, and professional installers should take appropriate provision to avoid service/user inadvertent contact within end applications.

- The NLP250 family has IPX0 rating and thus are not protected for ingress of water, cleaning agents and other liquids etc.

6.4 Leakage Current

The IT sector models (-96SxxJ) are designed for worst case leakage current of below 1.0 mA. The Medical sector models (-99Sxx) are designed for worst case leakage current of below 0.15 mA.

7. EMC

The NLP250 series has been designed to comply with the EMC requirements of EN55022 (FCC Part 15) for emissions and relevant sections of EN61000 (IEC 61000) for immunity.

7.1 Conducted Emissions

The applicable standard for conducted emissions is EN55022 (FCC Part 15). Conducted noise can appear as both differential mode and common mode noise currents. Differential mode noise is measured between the two input lines, with the major components occurring at the supply fundamental switching frequency and its harmonics. Common mode noise, a contributor to both radiated emissions and input conducted emissions, is measured between the input lines and system ground and can be broadband in nature.

The NLP250 power supplies have internal EMI filters to ensure the converters' conducted EMI levels comply with EN55022 (FCC Part 15) Class B and EN55022 (CISPR 22) Class B limits.

The EMI measurements are performed with resistive loads under forced air convection at maximum rated loading.

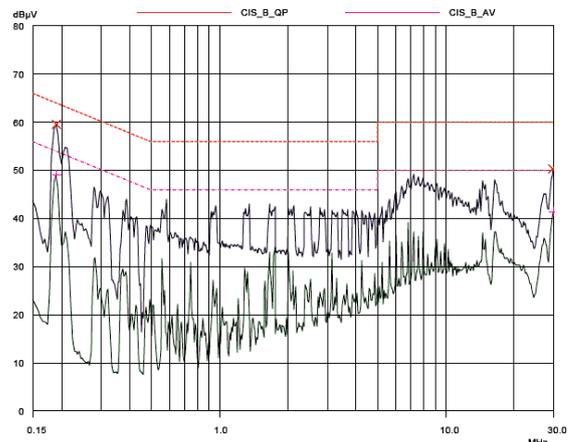


Figure 11 - Sample EN55022 Conducted EMI Measurement

7.2 Radiated Emissions

Unlike conducted EMI, radiated EMI performance in a system environment may differ drastically from that in a stand-alone power supply. The shielding effect provided by the system enclosure may bring the EMI level from Class A to Class B. It is thus recommended that radiated EMI be evaluated in a system environment.

The applicable standard is EN55022 Class A (FCC Part 15). Testing ac-dc convertors as a stand-alone component to the exact requirements of EN55022 can be difficult, because the standard calls for 1 m leads to be attached to the input and outputs and aligned such as to maximize the disturbance. In such a set-up, it is possible to form a perfect dipole antenna that very few ac-dc convertors

could pass. However, the standard also states that ‘an attempt should be made to maximize the disturbance consistent with the typical application by varying the configuration of the test sample’.

8. Applications

8.1 Mounting Considerations

Figure 9 shows the mounting hole locations for horizontal (bottom/flat) assembly within applications. The unit also contains fixing hole locations on the side of the U-Channel to allow for vertical (side) assembly which is shown in Figure 10.

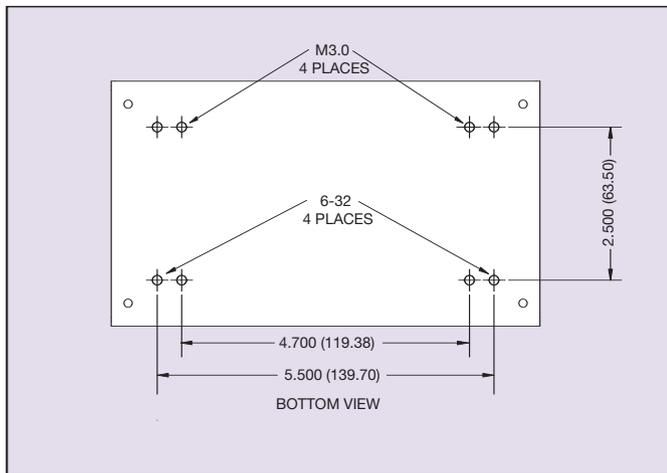


Figure 12 - Horizontal Mounting Hole Location Bottom View

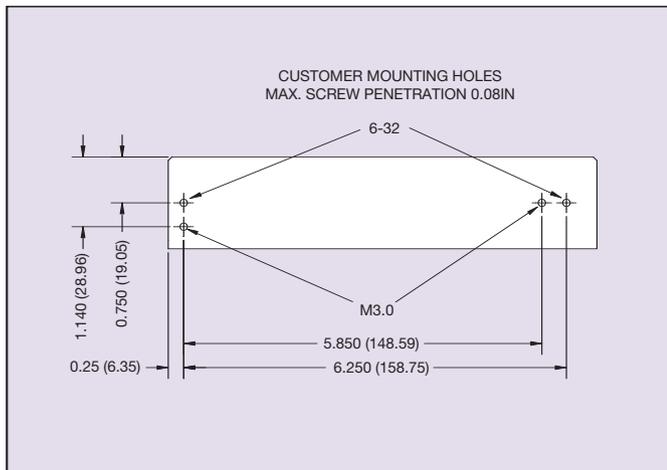


Figure 13 - Vertical Mounting Hole Location Side View

Metric and/or imperial screw fixings are catered for on the standard chassis. Maximum screw insertion depth (penetration) is 0.08 in (2.0 mm) maximum torque is 5.0 lbs/inch (0.57 Nm).

Note that the screws are not supplied as standard.

The input and output load cable/line should be separated within the application. The output cable/line should be twisted to improve Ripple/Noise sensitivity.

If at all possible, it is recommended that the control lines (if used) should be contained within shielded cable.

8.2 Output Voltage Adjustment

The main output voltage on all models is trimmable by $\pm 5\%$ of the nominal voltage setpoint via on board Single Turn Clock Potentiometer VR 7.

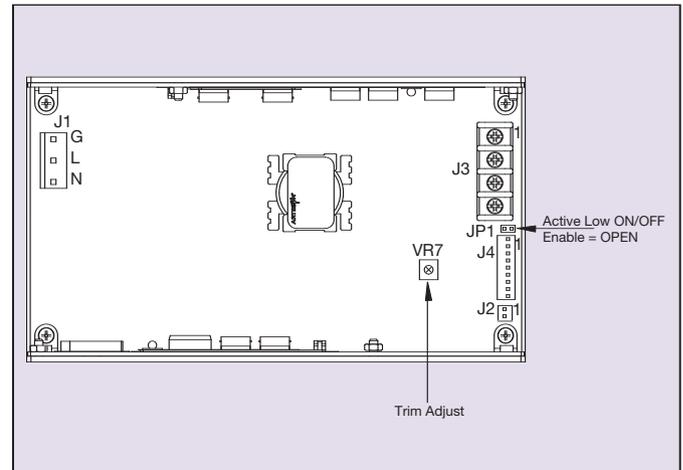


Figure 14 - Trim Potentiometer Location

Turning VR 7 clockwise decreases the output voltage. Turning anti-clockwise increases the output voltage. The overvoltage setting/trip points are not automatically adjusted when the unit is trimmed and remain at factory fixed settings which are well above the $+5\%$ trim up range.

8.3 Turn on Delay

Maximum turn on delay from application of input ac voltage until the output is within regulation is less than 2.0 seconds.

8.3.1 Remote ON/OFF Inactive: Mains AC Input applied

Here the NLP250 is allowed to startup under the influence of mains ac input voltage only and there is no external ON/OFF control logic. Turn-on delay is typically 880 ms.

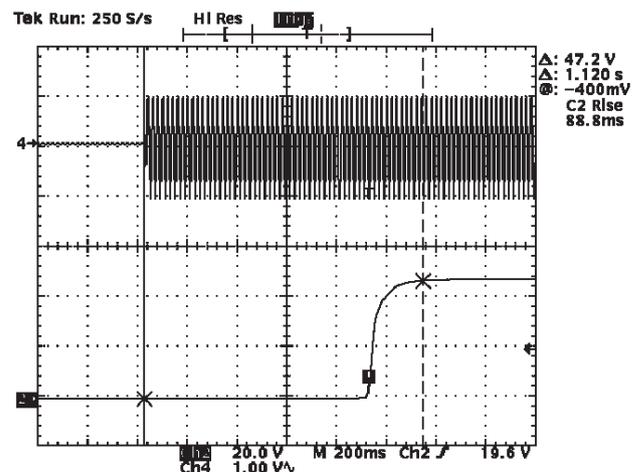


Figure 15 - Turn-on via AC Input Applied (Channel 1: ac Mains Input; Channel 2: Output Voltage (12 Vdc))

8.3.2 Remote ON/OFF active: Mains ac Input Present

Here the NLP250 is allowed to startup under the control of external ON/OFF control logic. The mains ac input voltage is already applied and the NLP250 is held OFF externally. Upon activation of the external ON/OFF (J4 pins 4 or 5) the NLP250 will startup. Turn-on delay is typically 320 ms.

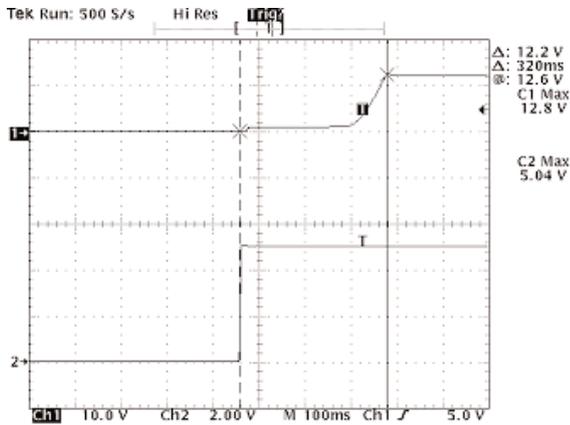


Figure 16 - Turn-on via Remote ON/OFF (Channel 1: Output Voltage (12 Vdc); Channel 2: Remote ON/OFF 5 Vdc Signal)

8.4 Remote Shutdown and Remote ON/OFF

The remote ON/OFF input allows external circuitry to put the NLP250 supply into a low dissipation sleep mode (i.e. inhibits the main output). Both active-high (PS OFF) and active low (PS ON) remote ON/OFF is available as standard.

The NLP250 series is factory supplied with the PS ON signal disabled by an installed link reference JP1 (See Figure 14).

PS OFF = J4 pin 4 Usage:

- The PS ON signal (J4 pin 5) should be disabled by installing link reference JP1 or connecting to Gnd (0 Vdc = J4 pin 6).

J4 pin 4 = Open (High) implies that the NLP250 unit is ON.
 J4 pin 4 = Closed (Low) implies that the NLP250 unit is OFF.

PS ON = J4 pin 5 Usage:

- The PS OFF (J4 pin 4) should be ignored by leaving it open. The PS ON signal (J4, pin 5) needs to be enabled by removing Link JP1 (See Figure 14).

J4 pin 5 = Open (High) implies that the NLP250 Unit is OFF.
 J4 pin 5 = Closed (Low) implies that the NLP250 Unit is ON.

The maximum external remote ON/OFF voltage that can be applied to the pins (J4 pin 4 and 5) is 15 Vdc. The maximum acceptable drive current is 10 mA and the minimum holding current is 1 mA. The remote ON/OFF input can be driven in a variety of ways. Internally to the NLP250 series the remote ON/OFF control logic is on the secondary control electronics. If the external remote ON/OFF signal originates on the secondary side, the remote ON/OFF input can be driven through a discrete device (e.g. a bipolar signal transistor) or directly from a logic gate output. The output of the logic gate may be an open-collector (or open-drain) device. If the external drive signal originates on the primary side, the remote ON/OFF input can be isolated or driven through an optocoupler (in order to maintain the safety isolation barrier).

8.5 Power Good Signal (PW OK)

The PW OK is an TTL/CMOS active HIGH signal that indicate the readiness of the power supply main output. It will be asserted HIGH (+5 V) within 500 ms after the output is within regulation during the start up. It also act as the 5 ms pre-warning signal to the system when the ac input is removed.

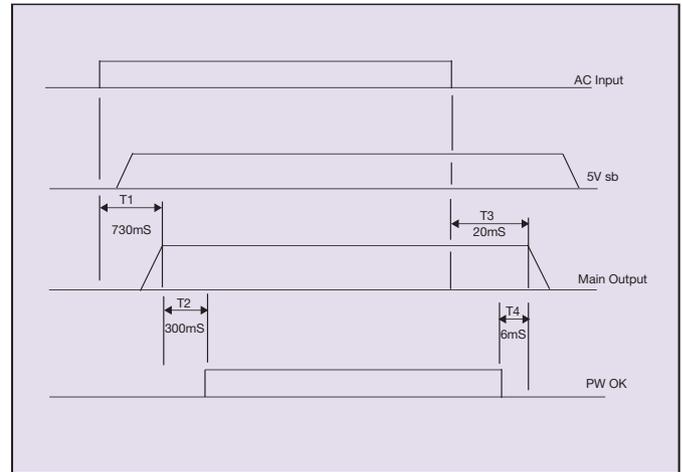


Figure 17 - Typical Values for PW OK Timing @ 85 Vac Input

Ref	Min.	Typ.	Max.	Description
T1	400 ms	730 ms	2000 ms	Main output turn-on upon ac input application
T2	100 ms	300 ms	500 ms	PW OK upon main output turn-on
T3	20 ms	27 ms	32 ms	Main output hold-up
T4	5 ms	6 ms	7 ms	PW OK upon main output turn-off (pre warning)

Table 10 - PW OK Timing

8.6 DC Power Good Signal (DC OK)

The DC OK is an TTL/CMOS active HIGH (+5 Vdc) signal that indicates the main output voltage of the power supply to be within -8% of the nominal regulation point.

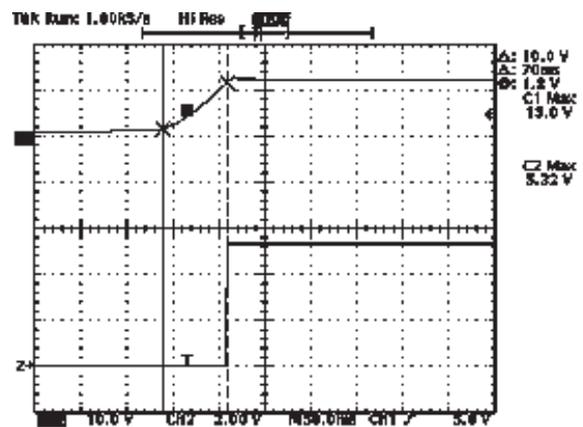


Figure 18 - Typical Turn-on Timing of DC OK with Respect to Main Output. (Channel 1: Output Voltage (12 Vdc); Channel 2: DC OK Signal Upon Output Rise)

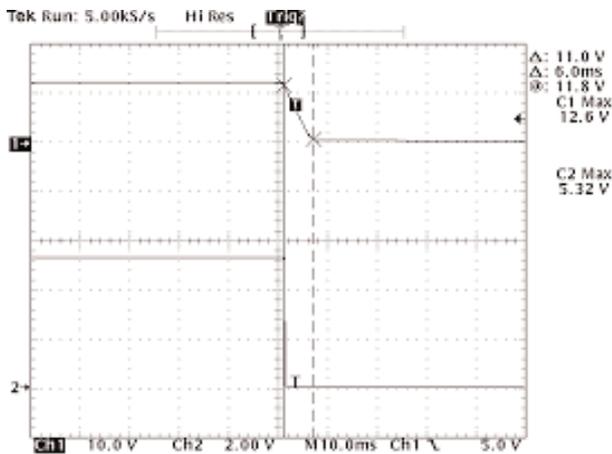


Figure 19 - Typical Turn-off Timing of DC OK with Respect to Main Output. (Channel 1: Output Voltage (12 Vdc); Channel 2: DC OK Signal Upon Fall)

8.7 Remote Sense Compensation

The remote sense compensation feature minimizes the effect of resistance in the distribution system and facilitates accurate voltage regulation at the load terminals or another selected point. A remote sense improves system performance by allowing the power supply to compensate for any 'IR' voltage drop between itself and the load. The remote sense lines will carry very little current and hence do not require a large cross-sectional area. However, if the sense lines are routed on a PCB, they should be located close to a ground plane in order to minimize any noise coupled onto the lines that might impair control loop stability. A small 100 nF ceramic capacitor can be connected at the point of load to decouple any noise on the sense wires. The module will compensate for a maximum drop of 0.2 Vdc of the nominal output voltage. However, if the unit is already trimmed up, the available remote sense compensation range will be correspondingly reduced. Remember that when using remote sense compensation all the resistance, parasitic inductance and capacitance of the distribution system are incorporated into the feedback loop of the power module. This can have an effect on the module's compensation capabilities, affecting its stability and dynamic response.

Notes

- Disconnection of the main output to the load should not occur while the unit is operating, otherwise the full load current may flow on the actual sense wires which may not be appropriately rated to carry such current.
- The remote sense is protected against reverse connection, and if +S and/or -S is connected to the wrong polarity, the power supply may shut down and lock out due to operation of protection circuits.
- Use of the remote sense is optional, if not used the sense pins can be left open.

8.8 Optimum Thermal Performance

The electrical operating conditions of the NLP250 namely:

- Input voltage, V_{in}
- Output voltage, V_o
- Output current, I_o

determine how much power is dissipated within the power supply.

The following parameters further influence the thermal stresses experienced by the converter:

- Ambient temperature
- Air velocity
- Thermal efficiency of the end system application
- Parts mounted on system application that may block airflow
- Real airflow characteristics at the PSU location

8.8.1 Thermal Derating Expectations

The maximum operating ambient temperature is 70 °C. However, the power supplies will have different ratings under natural and forced convection. Under forced air convection, the maximum output power is raised up to 250 W with 200 LFM for all models. Under natural convection, the maximum continuous output power is limited to 175 W for all models.

- For 24/48 V models operation above 50 °C (up to 70 °C), a 2.5% per °C power derating should be applied.
- For 12 V models operation above 35 °C (up to 70 °C), a 1.63% per °C power derating should be applied.

Note: For 5 Vsb/12 V fan output operation above 50 °C (up to 70 °C), a 2.5% per °C power derating should be applied, for example: the maximum load on the 5 Vsb is 5 W at 50 °C derating to 2.5 W at 70 °C.

Assuming the converter is operated within its thermal limits it can deliver rated output current I_{rated} . Note, however, that when the unit is trimmed up, the output current may need to be derated so that the output power does not exceed 250 W. The module will still deliver I_{rated} when trimmed down.

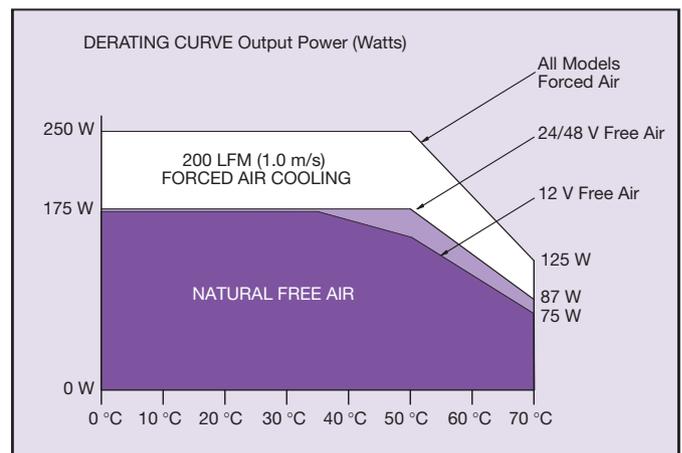


Figure 20 - Derating Curve

The direction of the airflow has different cooling effects. As shown in Figure 21, the recommended airflow direction is blowing from the output side of the power supply. The best airflow direction is from the two short sides. Airflow from the long sides is not recommended because the U-Channel will be restrictive.

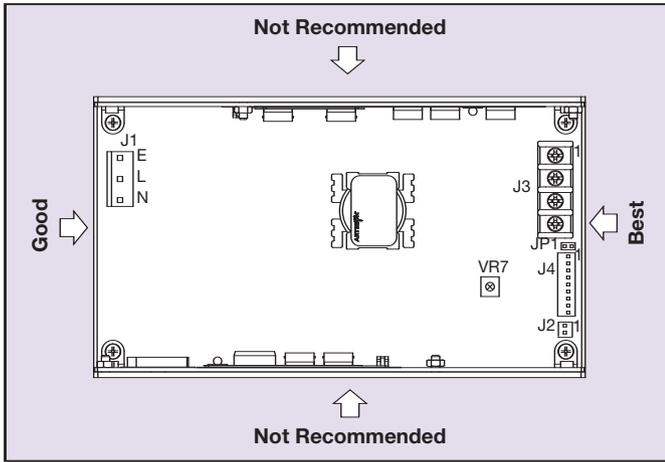


Figure 21 - Airflow Direction

The setup used for characterizing thermal performance and the effective airflow path are illustrated in Figure 22.

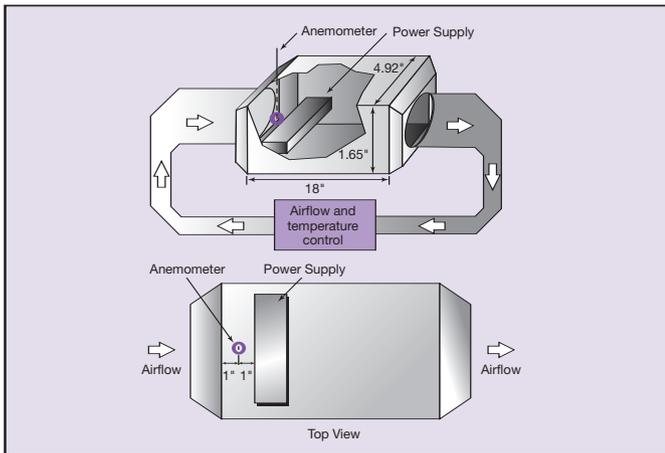


Figure 22 - Illustration of the Setup for Thermal Characterization

The power supply is tested in a wind tunnel of size 125 mm (4.92 inches) x 42 mm (1.65 inches).

8.8.2 Hot Spot Temperature Points

The maximum acceptable temperature measured at the thermal reference points is 120 °C. These thermal reference points are shown in Figure 23.

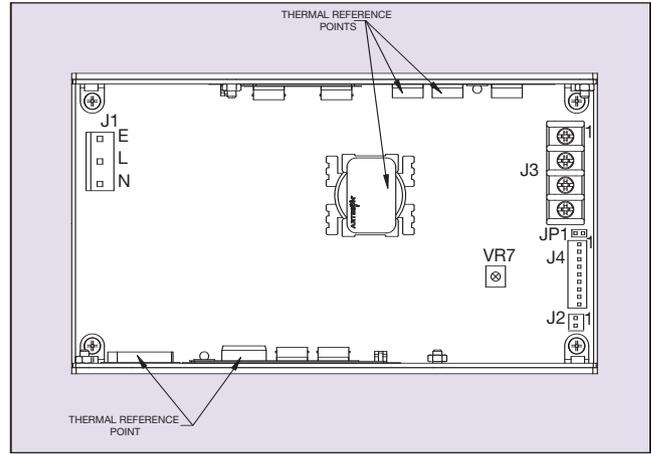


Figure 23 - Thermal Reference Point

Since the thermal performance is heavily dependent upon the final system application, the user needs to ensure the thermal reference point temperatures are kept within the recommended temperature rating. It is recommended that the thermal reference point temperatures are measured using a thermocouple or an IR camera. In order to comply with stringent Artesyn derating criteria the ambient temperature should never exceed 70 °C. Please contact Artesyn Technologies for further support.

8.9 Paralleling and Load Sharing Operation

8.9.1 Passive and Active Paralleling

The outputs of the NLP250 series can be connected in parallel with identical outputs of another similar NLP250 supply. However, under such passive current sharing conditions the output of one supply may reach maximum current before the paralleled supply begins to provide current.

Thus the NLP250 ‘R’ series are designed with active current share on the main output, in order to balance output currents between paralleled supplies. One wire common bus, active (democratic) current sharing scheme is employed to achieve current sharing between units. Here output current imbalance of the paralleled units is used to correct output voltage so that the total load current will be shared within ±10% of the full load rating of the output. To implement load sharing, the output voltages of paralleled outputs must be individually set to within 2% of each other.

Connector J4 Pin 3 (LS = load share) on the secondary side control connector is provided to connect the current sharing bus between paralleled ‘R’ units.

Simply direct connect the two LS pins from the paralleled units with the shortest wire possible in a daisy chain fashion. Care should be taken in order not to pass the LS bus through electrically ‘noisy’ parts of the system to prevent noise pick up, which will affect the accuracy of the current sharing and output regulation. If not in use, the LS pins may be left open.

8.9.2 Redundancy and Fault Tolerance

For true redundant and fault tolerant applications, an Or-ing element (diode or similar device) may be placed in each output of each paralleled supply to prevent interaction in the event of failure. Here the Or-ing element blocks fault current from affecting the remaining good units within the chain.

The Or-ing element may be factory supplied located within the power supply, on the main and auxiliary outputs (refer to ‘R’ options within the model nomenclature on page 2).

Notes

- The remote sensing included in the NLP250 series is capable of sensing the common bus after the Or-ing elements, thereby maintaining regulation limits at the remote sense point. When Or-ing elements are used, load sharing may be used to balance currents.
- When operating alone, the J4 pin # 3 LS signal may be used to measure output current where $4.8\text{ V} \pm 10\%$ equals 100% load.
- The maximum number of same rated NLP250 units that can be connected in series is unlimited, provided that there is a monitoring mechanism in the user system to make sure that the system will draw n X rated full load only after there are n X number of PW OK signals asserted HIGH.

8.10 Load Types and Output Capacitance

The NLP250 series is designed for both resistive and constant current load. The maximum rated value of output capacitance for each model will differ, due to equivalent series resistance (ESR) of load capacitance types.

Sample DVT testing results:

12 V model = 10,800 μF electrolytic
 24 V model = 2,850 μF electrolytic
 48 V model = 1,000 μF electrolytic

Contact your local Artesyn Technologies representative for further information if larger output capacitance values are required in the application.

8.11 Reflected Ripple Current and Output Ripple and Noise Measurement

The measurement set-up outlined in Figure 26 has been used for output voltage ripple and noise measurements on the NLP250 series. When measuring output ripple and noise, a $50\ \Omega$ coaxial cable with a $50\ \Omega$ termination should be used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies. Measurements were taken directly at the output terminals via a 6" output cable (wiring = twisted pair) with a 20 MHz bandwidth. A $10\ \mu\text{F}$ tantalum capacitor and a $0.1\ \mu\text{F}$ ceramic capacitor are used across the test points during the measurement. The ripple and noises are measured at 60 Hz input with North American line (90-132 Vac) or 50 Hz input with European line (180-264 Vac). Please refer to datasheets for the specification and Figure 26 for the test setup and measurement recommendations.

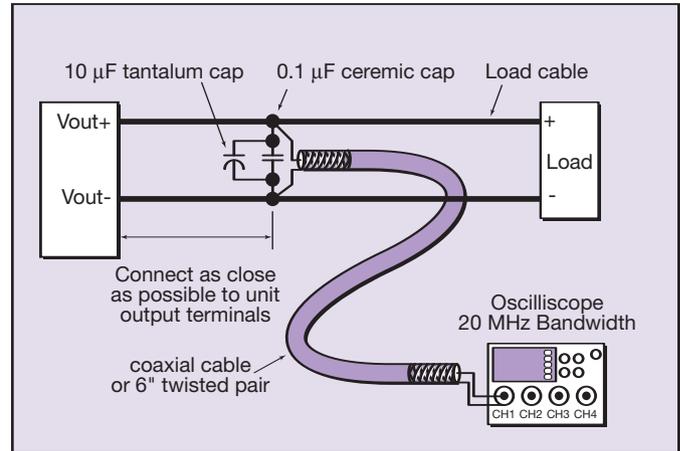


Figure 24 - Illustration of Setup for Ripple and Noise Measurement

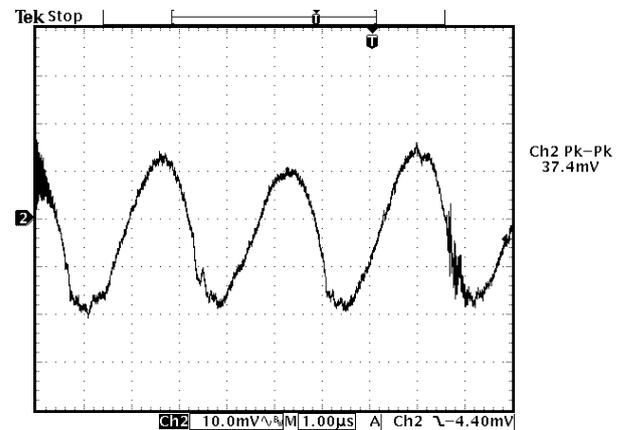


Figure 25 - Sample Ripple and Noise Measurement (12 Vdc Model)

Vin (Vac)	OUTPUT LOADING		RIPPLE & NOISE		SPEC (48 V)
	5 Vsb	48 V	(mVp-p, 5 Vsb)	(mVp-p, 48 V)	(mVp-p)
85	0.0	0.0	6.0	46	<480
85	0	5.25	8.4	86	<480
85	1	0	22.0	44	<480
85	1	5.1	26.0	90	<480
264	0	0	8.0	54	<480
264	0	5.25	8.0	80	<480
264	1	0	23.6	56	<480
264	1	5.1	24.8	86	<480

Table 11 - Sample Ripple and Noise For 48 V Model
 Tested with ripple filter 10 μF Tand-Cap in parallel with 0.1 μF ceramic cap

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