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NH Series 270 Vin DC/DC Converters

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Mar 05, 2009

NH50

50 Watts Output Power

SINGLE OUTPUT



How to Order:

NH 50 S M / 5 - A - D

| | |
|--------------------------------|--|
| Series | |
| Total Output Power | |
| Single Output | |
| Industrial (I) or Military (M) | |

Output Voltage: Options:
 Maximum current A- pins out side of unit
 as stated in chart B- pins out bottom of unit
 C- pins out top of unit
 D- through hole inserts
 (STD threaded)
 I - M2.5 inserts

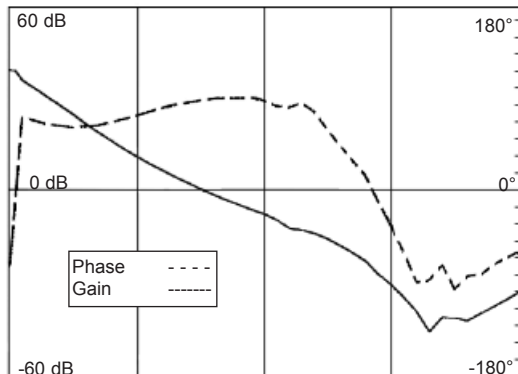
INPUT CHARACTERISTICS

| | PER CHANNEL | | | Units |
|--|-------------|-------|------|-------|
| | Min. | Typ. | Max. | |
| Input Voltage | 200 | 270 | 400 | Vdc |
| Brown Out (75% of Full Load)(fig. I)* | 180 | | | Vdc |
| No Load Power Dissipation | | 2 | 3 | Watt |
| Inrush Charge (fig. VII)* | | 0.12 | 0.2 | mc |
| Reflective Ripple Current (fig. VIII)* | | 100 | | mA |
| Logic Disable Current (Sink) | | 5 | 6 | mA |
| Logic Disable Power In | | 2 | 3 | W |
| Input Ripple Rejection (120 Hz) | | 75 | | dB |
| Input Ripple Rejection (800 Hz) | | 60 | | dB |
| Efficiency (FL) (fig. II, III)* | 75 | 80-86 | | % |
| 3.3 Vdc Output (FL) | 70 | 74 | | % |
| 2 Vdc Output (FL) | 60 | 65 | | % |

EMI: Units conform to MIL-STD-461D (on the input leads) with companion filter

Input Transient: Units conform to MIL-STD-704D for transients up to 500V for 0.1 second

STABILITY



FEATURES

- .38 Inch Profile
- Power Good**
- Synchronization**
- Remote Turn On (TTL)**
- Output Voltage Trim Pin**
- Over Temperature Protection
- Output Overvoltage/Overcurrent Protection
- 100% Environmental Screening (Military Version)
- Outputs Isolated Allowing Any Combination of Output Voltages

SELECTION CHART

| Nominal Output Voltage | Output Current (Amps) | Model Number (Industrial) | Model Number (Military) |
|------------------------|-----------------------|---------------------------|-------------------------|
| 2 | 10 | NH50SI/2-A | NH50SM/2-A |
| 3.3 | 10 | NH50SI/3.3-A | NH50SM/3.3-A |
| 5 | 10 | NH50SI/5-A | NH50SM/5-A |
| 5.2 | 9.6 | NH50SI/5.2-A | NH50SM/5.2-A |
| 12 | 4.2 | NH50SI/12-A | NH50SM/12-A |
| 15 | 3.3 | NH50SI/15-A | NH50SM/15-A |
| 24 | 2.1 | NH50SI/24-A | NH50SM/24-A |
| 28 | 1.8 | NH50SI/28-A | NH50SM/28-A |

OUTPUT CHARACTERISTICS

| | PER CHANNEL | | | Units |
|---|-------------|---------|------|--------------------|
| | Min. | Typ. | Max. | |
| Set Point Accuracy | | | 1 † | % V _{out} |
| Load Regulation | | 0.15 | 0.2 | % V _{out} |
| Line Regulation | | 0.15 | 0.2 | % V _{out} |
| Ripple P-P (10 MHz) (fig. IV)* | | | 100 | mV |
| 100mV or 1% V _{out} , whichever is greater | | | | |
| Trim Range | 90 | | 110 | % V _{out} |
| Remote Sense Compensation | | 0.5 | | Vdc |
| Overvoltage Protection | | 125 | | % V _{out} |
| Current Sharing | | ±10 | | % I _{out} |
| Transient Response (Recovery to 1%V _{out}) Time/Overshoot | | | | |
| 20-80% Load | | 500/500 | | µS/mV |
| Low Line - High Line | | 500/500 | | µS/mV |
| 50-100% Load | | 500/500 | | µS/mV |
| Temperature Drift | | .01 | .05 | %/°C |
| Long Term Drift | | .01 | .05 | %/1Khrs |
| Current Limit | | 130 | | % I _{out} |
| Short Circuit Current (Burp Mode) 25 | | | 75 | % I _{out} |
| Turn On Time (fig. XI)* | | 60 | | mS |
| Logic Turn On Time (fig. IX)* | | 1.0 | | mS |

† 1% or 50mV, whichever is greater

* Figures on page 10

** Features referenced to output ground

All specifications are typical @+25°C with nominal input voltage under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

*HIGH DENSITY
DC TO DC CONVERTERS*

Industrial & Military Grades

TEMPERATURE CHARACTERISTICS

| | Min. | Typ. | Max. | Units |
|-----------------------------------|------|------|------|-------|
| Operating | -55 | | +100 | °C |
| Storage (Ambient) | -55 | | +125 | °C |
| Over Temperature Shutdown | | +105 | | °C |
| Thermal Resistance Case - Ambient | | 11 | | °C/W |

ENVIRONMENTAL SCREENING - M MODEL

Stabilization Bake: +125°C for 24 hours similar to Mil-Std-883, M1008.2, Condition B

Temperature Cycling: 10 cycles at -55°C to +125°C (transition period 36 minutes) similar to Mil-Std-883, M1010, Condition B

Burn-in: 160 hours at +85°C min.

Final Testing

ENVIRONMENTAL SCREENING - I MODEL

Burn-in: 16 hours at +85°C min.

Final Testing

See "Guide to Operation" for full details.

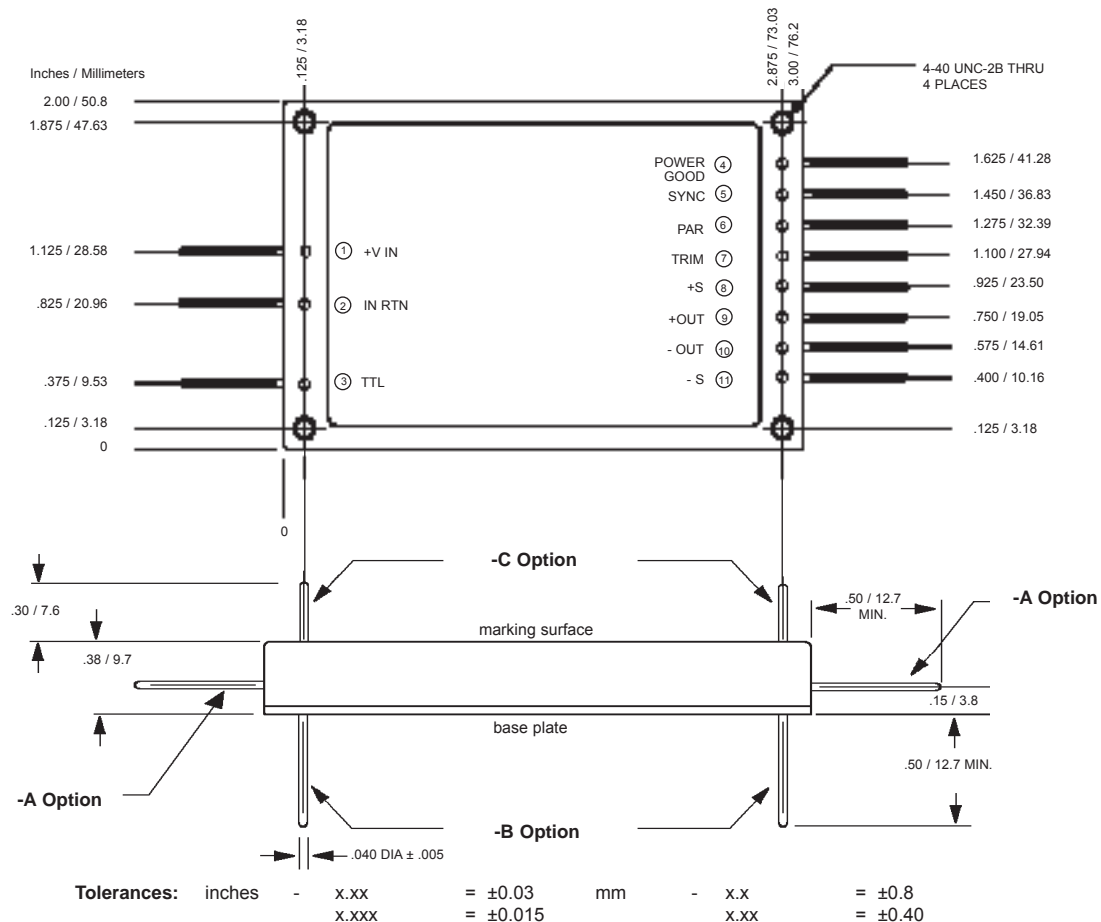
ISOLATION CHARACTERISTICS

| | Min. | Typ. | Max. | Units |
|------------------------------------|------|-------|------|-------|
| Isolation: | | | | |
| Input to Output | 1000 | | | Vdc |
| Output to Base | 500 | | | Vdc |
| Input to Base | 1000 | | | Vdc |
| Input to Output Capacitance | | 0.022 | | µf |
| Insulation Resistance (@50 Vdc) 50 | | | | MOhm |

MECHANICAL CHARACTERISTICS

| | | |
|----------|-------------------|-----------------------------------|
| Weight | 4.2 | oz. |
| | 120 | grams |
| Size | 3.0 x 2.0 x 0.38 | inch |
| | 76.2 x 50.8 x 9.7 | mm |
| Volume | 2.28 | inch ³ |
| | 37.5 | cm ³ |
| Material | Pin | Brass (Solder Plating) |
| | Baseplate | Aluminum 5052-H32 |
| | Case | 28 Gauge Steel (cold rolled) |
| Finish | | Nickel Plating |
| Mounting | Standard | 4-40 inserts provided in basplate |
| | I Option | M2.5 metric inserts (4 places) |
| | D Option | 0.115 DIA thru holes (4 places) |

CASE DRAWINGS



All specifications are typical @+25°C with nominal input voltage under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

NH100

100 Watts Output Power

SINGLE & DUAL OUTPUTS



How to Order:

NH 100 D I / 5 / 15 - A - D

| | | |
|--------------------------------|------------------------------------|---|
| Series | Output Voltage: | Options: |
| Total Output Power | Maximum current as stated in chart | A- pins out side of unit B- pins out bottom of unit C- pins out top of unit D- through hole inserts (STD threaded) I - M2.5 inserts |
| Single (S), Dual (D) Output | | |
| Industrial (I) or Military (M) | | |

Model Numbering Example:
To order a 100 watt, 15 Vout (single output), industrial grade power supply with pins out the side, the model number would be: NH100SI/15-A. Military grade would be NH100SM/15-A. To order a 100 watt, dual output, 15 Vdc and 15 Vdc, industrial grade power supply with pins out of the top, the model number would be: NH100DI/15/15-C. Dual output, 12 Vdc and 15 Vdc, military grade, would be NH100DM/12/15-C. When ordering a dual output unit, the first output voltage in the model number is located on channel 1 and the second model number is located on channel 2 (see case drawing for details).

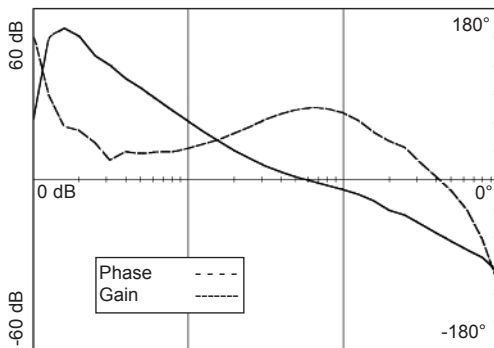
INPUT CHARACTERISTICS

| | PER CHANNEL | | | Units |
|--|-------------|------|------|-------|
| | Min. | Typ. | Max. | |
| Input Voltage | 200 | 270 | 400 | Vdc |
| Brown Out (75% of Full Load) (fig. I)* | 180 | | | Vdc |
| No Load Power Dissipation | | 4 | 6 | Watt |
| Inrush Charge (fig. VII)* | | 0.24 | 0.4 | mc |
| Reflective Ripple Current (fig. VIII)* | | 200 | | mA |
| Logic Disable Current (Sink) | | 10 | | mA |
| Logic Disable Power In | | 4 | 5 | W |
| Input Ripple Rejection (120 Hz) | | 75 | | dB |
| Input Ripple Rejection (800 Hz) | | 60 | | dB |
| Efficiency (FL) (fig. II, III)* | 75 | 80 | | % |
| 3.3 Vdc Output (FL) | 70 | 74 | | % |
| 2 Vdc Output (FL) | 60 | 65 | | % |

EMI: Units conform to MIL-STD-461D (on the input leads) with companion filter

Input Transient: Units conform to MIL-STD-704D for transients up to 500V for 0.1 second

STABILITY



FEATURES

- .38 Inch Profile
- Power Good***
- Synchronization**
- Remote Turn On (TTL)***
- Output Voltage Trim Pin**
- Single and Dual Outputs
- Over Temperature Protection
- N+1 Redundancy (Single Output)
- Output Overvoltage/Overcurrent Protection
- 100% Environmental Screening (Military Version)
- Outputs Isolated Allowing Any Combination of Output Voltages

SELECTION CHART

| Nominal Output Voltage | Single Output Current (Amps) | Dual Per Channel Current (Amps) |
|------------------------|------------------------------|---------------------------------|
| 2 | 20 | 10 |
| 3.3 | 20 | 10 |
| 5 | 20 | 10 |
| 5.2 | 19.2 | 9.6 |
| 12 | 8.4 | 4.2 |
| 15 | 6.7 | 3.3 |
| 24 | 4.2 | 2.1 |
| 28 | 3.6 | 1.8 |

OUTPUT CHARACTERISTICS

| | PER CHANNEL | | | |
|---|-------------|---------|------|--------------------|
| | Min. | Typ. | Max. | Units |
| Set Point Accuracy | | | 1 † | % V _{out} |
| Load Regulation | | | 0.5 | % V _{out} |
| Line Regulation | | | 0.5 | % V _{out} |
| Ripple P-P (10 MHz) (fig. IV)* 100mV or 1% V _{out} , whichever is greater | | | 100 | mV |
| Trim Range | | ±10 | | % V _{out} |
| Remote Sense Compensation | | 0.5 | | Vdc |
| Overvoltage Protection | | 125 | | % V _{out} |
| Current Sharing | | ±10 | | % I _{out} |
| Transient Response (Recovery to 1%V _{out}) Time/Overshoot | | | | |
| 20-80% Load | | 500/500 | | µS/mV |
| Low Line - High Line | | 500/500 | | µS/mV |
| 50-100% Load | | 500/500 | | µS/mV |
| Temperature Drift | | .05 | | %/°C |
| Long Term Drift | | .05 | | %/1KHrs |
| Current Limit | | 130 | | % I _{out} |
| Short Circuit Current (Burp Mode) | 25 | | 75 | % I _{out} |
| Turn On Time (fig. XI)* | | 60 | | mS |
| Logic Turn On Time (fig. IX)* | | 1.0 | | mS |

† 1% or 50mV, whichever is greater

* Figures on page 10

** Features referenced to Output Ground

*** Features referenced to Channel 1 Output Ground

All specifications are typical @+25°C with nominal input voltage under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

*HIGH DENSITY
DC TO DC CONVERTERS*

Industrial & Military Grades

TEMPERATURE CHARACTERISTICS

| | Min. | Typ. | Max. | Units |
|-----------------------------------|------|------|------|-------|
| Operating | -55 | | +100 | °C |
| Storage (Ambient) | -55 | | +125 | °C |
| Over Temperature Shutdown | | +105 | | °C |
| Thermal Resistance Case - Ambient | | 11 | | °C/W |

ENVIRONMENTAL SCREENING - M MODEL

| | |
|----------------------|--|
| Stabilization Bake: | +125°C for 24 hours similar to Mil-Std-883, M1008.2, Condition B |
| Temperature Cycling: | 10 cycles at -55°C to +125°C (transition period 36 minutes) similar to Mil-Std-883, M1010, Condition B |
| Burn-in: | 160 hours at +85°C min. |
| Final Testing | |

ENVIRONMENTAL SCREENING - I MODEL

| | |
|---------------|------------------------|
| Burn-in: | 16 hours at +85°C min. |
| Final Testing | |

See "Guide to Operation" for full details.

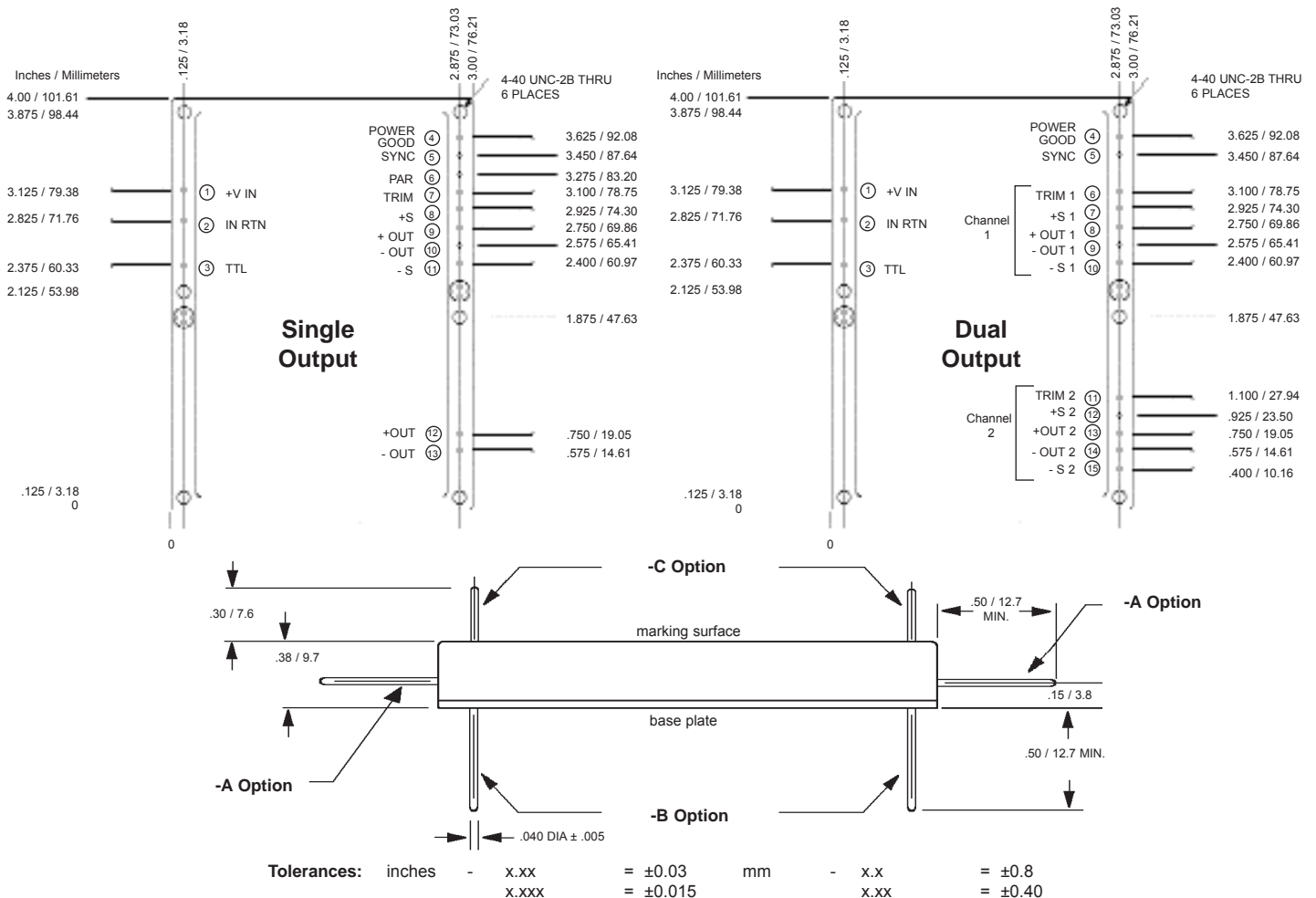
ISOLATION CHARACTERISTICS

| | Min. | Typ. | Max. | Units |
|--------------------------------------|------|-------|------|-------|
| Isolation: | | | | |
| Input to Output | 1000 | | | Vdc |
| Output to Base | 500 | | | Vdc |
| Input to Base | 1000 | | | Vdc |
| Input to Output Capacitance (single) | | 0.044 | | µf |
| Input to Output Capacitance (dual) | | 0.022 | | µf |
| Insulation Resistance (@50 Vdc) | 50 | | | MOhm |

MECHANICAL CHARACTERISTICS

| | | |
|----------|--------------------|-----------------------------------|
| Weight | 8.4 | oz. |
| | 240 | grams |
| Size | 3.0 x 4.0 x 0.38 | inch |
| | 76.2 x 101.6 x 9.7 | mm |
| Volume | 4.56 | inch ³ |
| | 75.1 | cm ³ |
| Material | Pin | Brass (Solder Plating) |
| | Baseplate | Aluminum 5052-H32 |
| | Case | 28 Gauge Steel (cold rolled) |
| Finish | | Nickel Plating |
| Mounting | Standard | 4-40 inserts provided in basplate |
| | I Option | M2.5 metric inserts (6 places) |
| | D Option | 0.115 DIA thru holes (6 places) |

CASE DRAWINGS



All specifications are typical @+25°C with nominal input voltage under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

NH150

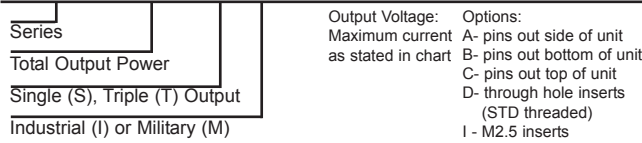
150 Watts Output Power

SINGLE & TRIPLE OUTPUTS



How to Order:

NH 150 T M / 5/12/15 - A - D



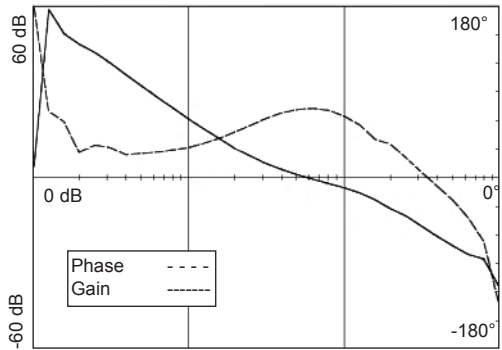
Model Numbering Example:
 To order a 150 watt, 15 Vout (single output), industrial grade power supply with pins out the bottom, the model number would be: NH150SI/15-B. Military grade would be NH150SM/15-B. To order a 150 watt, triple output, 15 Vdc and 15 Vdc and 5.2 Vdc, industrial grade power supply with pins out of the top, the model number would be: NH150TI/15/15/5.2-C. Triple output, 12 Vdc and 15 Vdc and 3.3 Vout, military grade, would be NH150TM/12/15/3.3-C. When ordering a Triple output unit, the first output voltage in the model number is located on channel 1 and the second output voltage is located on channel 2, and the third is located on channel 3 (see case drawing for details).

INPUT CHARACTERISTICS

| | PER CHANNEL | | | Units |
|--|-------------|------|------|-------|
| | Min. | Typ. | Max. | |
| Input Voltage | 200 | 270 | 400 | Vdc |
| Brown Out (75% of Full Load) (fig. I)* | 180 | | | Vdc |
| No Load Power Dissipation | | 6 | 9 | Watt |
| Inrush Charge (fig. VII)* | | 0.36 | 0.6 | mc |
| Reflective Ripple Current (fig. VIII)* | | 300 | | mA |
| Logic Disable Current (Sink) | | 15 | | mA |
| Logic Disable Power In | | 6 | 7 | W |
| Input Ripple Rejection (120 Hz) | | 75 | | dB |
| Input Ripple Rejection (800 Hz) | | 60 | | dB |
| Efficiency (FL) (fig. II, III)* | 75 | 80 | | % |
| 3.3 Vdc Output (FL) | 70 | 74 | | % |
| 2 Vdc Output (FL) | 60 | 65 | | % |

EMI: Units conform to MIL-STD-461D (on the input leads) with companion filter
 Input Transient: Units conform to MIL-STD-704D for transients up to 500V for 0.1 second

STABILITY



FEATURES

- .38 Inch Profile
- Power Good***
- Synchronization**
- Remote Turn On (TTL)***
- Output Voltage Trim Pin**
- Single and Triple Outputs
- Over Temperature Protection
- N+1 Redundancy (Single Output)
- Output Overvoltage/Overcurrent Protection
- 100% Environmental Screening (Military Version)
- Outputs Isolated Allowing Any Combination of Output Voltages

SELECTION CHART

| Nominal Output Voltage | Single Output Current (Amps) | Triple Per Channel Current (Amps) |
|------------------------|------------------------------|-----------------------------------|
| 2 | 30 | 10 |
| 3.3 | 30 | 10 |
| 5 | 30 | 10 |
| 5.2 | 28.8 | 9.6 |
| 12 | 12.6 | 4.2 |
| 15 | 10 | 3.3 |
| 24 | 6.3 | 2.1 |
| 28 | 5.4 | 1.8 |

OUTPUT CHARACTERISTICS

| | PER CHANNEL | | | Units |
|--|-------------|---------|------|--------------------|
| | Min. | Typ. | Max. | |
| Set Point Accuracy | | | 1 † | % V _{out} |
| Load Regulation | | | 0.5 | % V _{out} |
| Line Regulation | | | 0.5 | % V _{out} |
| Ripple P-P (10 MHz) (fig. IV)* | | | 100 | mV |
| <i>100mV or 1% Vout, whichever is greater</i> | | | | |
| Trim Range | | ±10 | | % V _{out} |
| Remote Sense Compensation | | 0.5 | | Vdc |
| Overvoltage Protection | | 125 | | % V _{out} |
| Current Sharing | | ±10 | | % I _{out} |
| Transient Response (Recovery to 1%Vout) Time/Overshoot | | | | |
| 20-80% Load | | 500/500 | | µS/mV |
| Low Line - High Line | | 500/500 | | µS/mV |
| 50-100% Load | | 500/500 | | µS/mV |
| Temperature Drift | | .05 | | %/°C |
| Long Term Drift | | .05 | | %/1KHrs |
| Current Limit | | 130 | | % I _{out} |
| Short Circuit Current (Burp Mode) | 25 | | 75 | % I _{out} |
| Turn On Time (fig. XI)* | | 60 | | mS |
| Logic Turn On Time (fig. IX)* | | 1.0 | | mS |

† 1% or 50mV, whichever is greater
 * Figures on page 10
 ** Features referenced to output ground.
 *** Features referenced to Channel 1 Output Ground

All specifications are typical @+25°C with nominal input voltage under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

**HIGH DENSITY
DC TO DC CONVERTERS**

Industrial & Military Grades

TEMPERATURE CHARACTERISTICS

| | Min. | Typ. | Max. | Units |
|-----------------------------------|------|------|------|-------|
| Operating | -55 | | +100 | °C |
| Storage (Ambient) | -55 | | +125 | °C |
| Over Temperature Shutdown | | +105 | | °C |
| Thermal Resistance Case - Ambient | | 11 | | °C/W |

ENVIRONMENTAL SCREENING - M MODEL

| | |
|----------------------|--|
| Stabilization Bake: | +125°C for 24 hours similar to Mil-Std-883, M1008.2, Condition B |
| Temperature Cycling: | 10 cycles at -55°C to +125°C (transition period 36 minutes) similar to Mil-Std-883, M1010, Condition B |
| Burn-in: | 160 hours at +85°C min. |
| Final Testing | |

ENVIRONMENTAL SCREENING - I MODEL

| | |
|---------------|------------------------|
| Burn-in: | 16 hours at +85°C min. |
| Final Testing | |

See "Guide to Operation" for full details

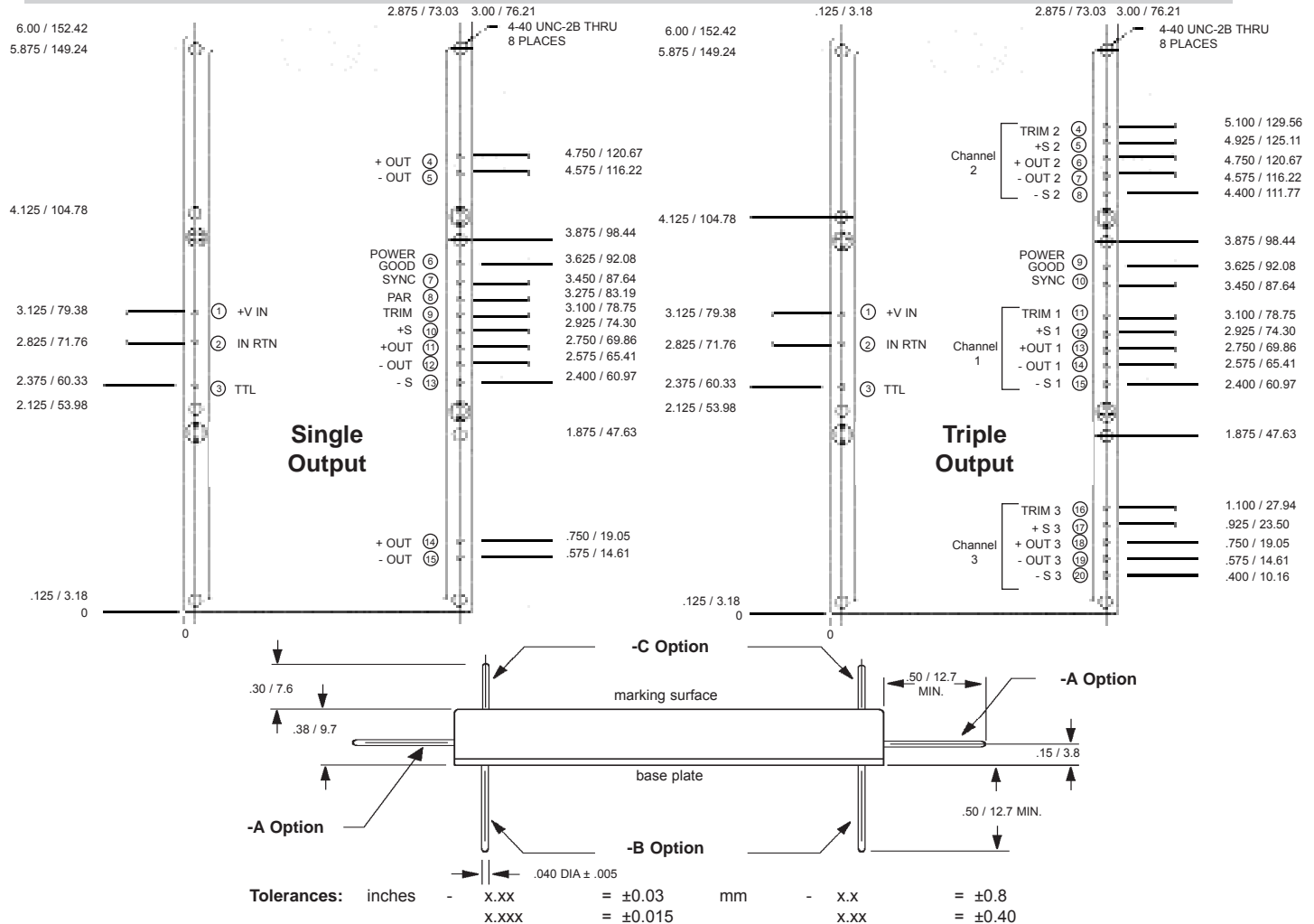
ISOLATION CHARACTERISTICS

| | Min. | Typ. | Max. | Units |
|--------------------------------------|------|-------|------|-------|
| Isolation: | | | | |
| Input to Output | 1000 | | | Vdc |
| Output to Base | 500 | | | Vdc |
| Input to Base | 1000 | | | Vdc |
| Input to Output Capacitance (single) | | 0.066 | | µf |
| Input to Output Capacitance (triple) | | 0.022 | | µf |
| Insulation Resistance (@50 Vdc) 50 | | | | MOhm |

MECHANICAL CHARACTERISTICS

| | | | |
|----------|--------------------|-----------|-----------------------------------|
| Weight | 12.6 | 360 | oz. |
| | | | grams |
| Size | 3.0 x 6.0 x 0.38 | | inch |
| | 76.2 x 152.4 x 9.7 | | mm |
| Volume | 6.84 | 112.6 | inch ³ |
| | | | cm ³ |
| Material | Pin | Baseplate | Case |
| | | | Brass (Solder Plating) |
| | | | Aluminum 5052-H32 |
| | | | 28 Gauge Steel (cold rolled) |
| Finish | | | Nickel Plating |
| Mounting | Standard | I Option | D Option |
| | | | 4-40 inserts provided in basplate |
| | | | M2.5 metric inserts (8 places) |
| | | | 0.115 DIA thru holes (8 places) |

CASE DRAWINGS



All specifications are typical @+25°C with nominal input voltage under full output load conditions, unless otherwise noted. Specifications subject to change without notice.

NHF150

EMI Filter



How to Order:

NHF 150 - A - D

| | |
|--------------------|--|
| Series | Options: |
| Total Output Power | A- pins out side of unit |
| | B- pins out bottom of unit |
| | C- pins out top of unit |
| | D- through hole inserts (STD threaded) |
| | I - M2.5 inserts |

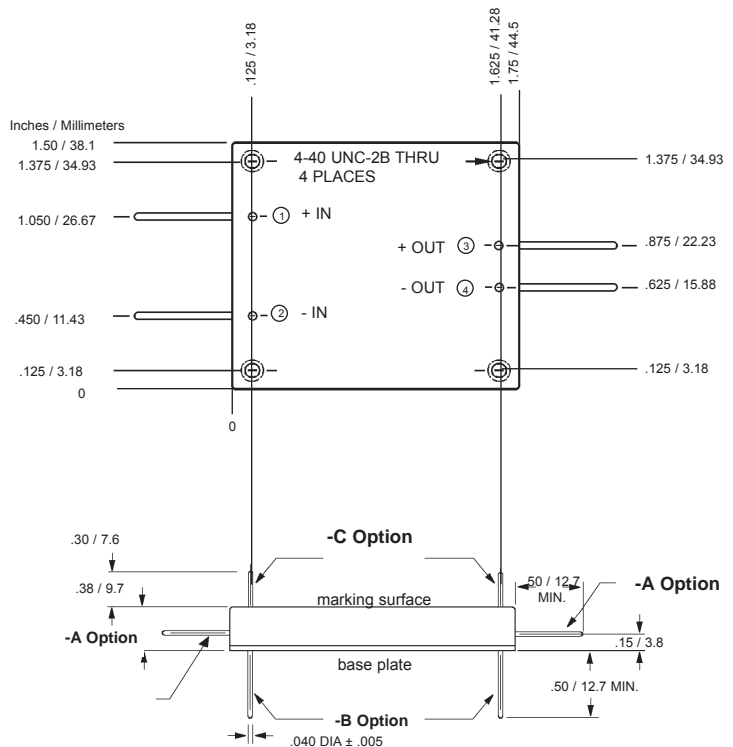
FEATURES

- MIL-STD-461D Compliance CE101 and CE102
- Thermally Non-dissipative device
- Less than 1.0 Volt Drop Across the NHF150
- Does Not Require External Components
- Meets Environmental Requirements of MIL-STD-810E and MIL-STD-901C
- For Use With NH50, NH100, and NH150 Series DC/DC Converters

SPECIFICATIONS

| | | |
|--|-------------------|-----------------------------------|
| Input Voltage (Maximum) | 500 | Vdc |
| Rated Output Current | 1 | A |
| Isolation (Input/Output to Case) | 1000 | Vdc |
| Operating Temperature | 100 | °C |
| Storage Temperature | 125 | °C |
| Insulation Resistance (measured @ 50Vdc) | 50 | M Ohm |
| Weight | 1.72 | oz. |
| | 48.65 | grams |
| Size | 1.75 x 1.5 x 0.38 | inch |
| | 44.5 x 38.1 x 9.7 | mm |
| Volume | 1.00 | inch ³ |
| | 16.5 | cm ³ |
| Material | Pin | Brass (Solder Plating) |
| | Baseplate | Aluminum 5052-H32 |
| | Case | 28 Gauge Steel (cold rolled) |
| Finish | | Nickel Plating |
| Mounting | Standard: | 4-40 inserts provided in basplate |
| | I Option: | M2.5 metric inserts (4 places) |
| | D Option: | 0.115 DIA thru holes (4 places) |

CASE DRAWINGS

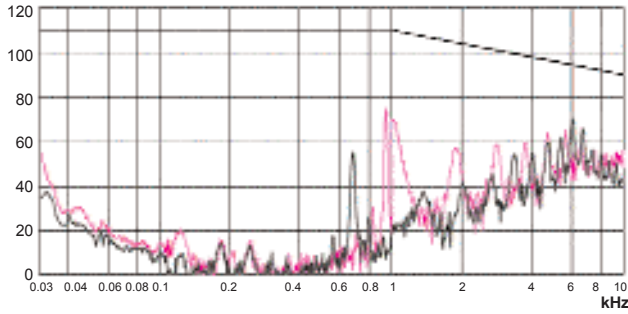


| | | | | |
|-------------|--------|---|-------|----------|
| Tolerances: | inches | - | x.xx | = ±0.03 |
| | | | x.xxx | = ±0.015 |
| | mm | - | x.X | = ±0.8 |
| | | | x.XX | = ±0.40 |

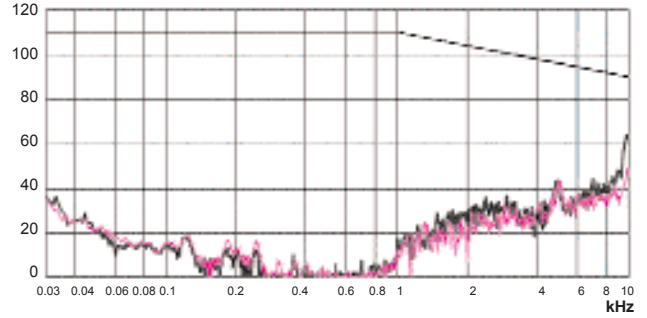
EMI COMPLIANCE GRAPHS

Mil-STD-461D, CE101

270 V_{in} - 150 watts



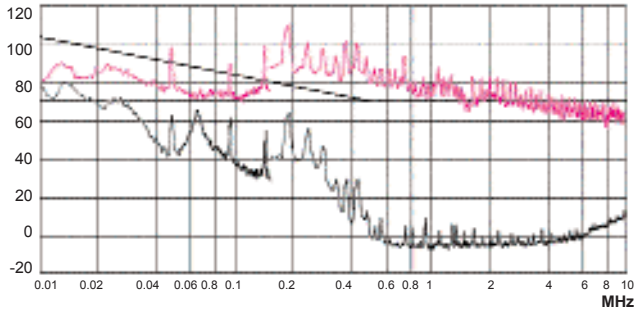
270 V_{in} - 50 watts



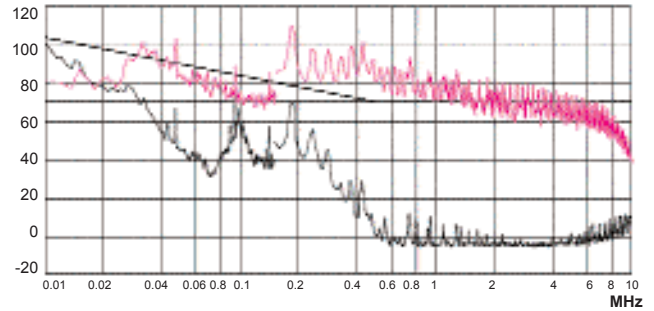
■ Without NHF150
■ With NHF150

Mil-STD-461D, CE102

270 V_{in} - 150 watts



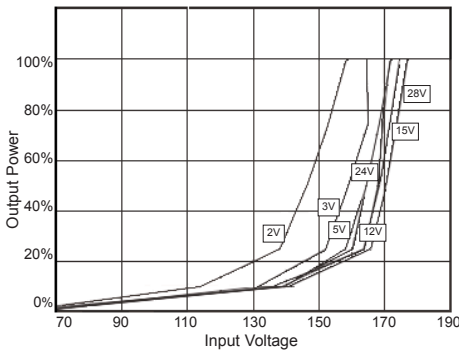
270 V_{in} - 50 watts



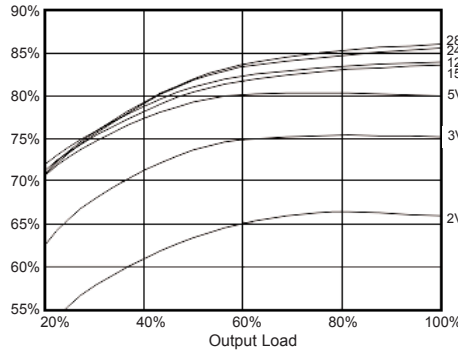
■ Without NHF150
■ With NHF150

NH Performance Characteristics

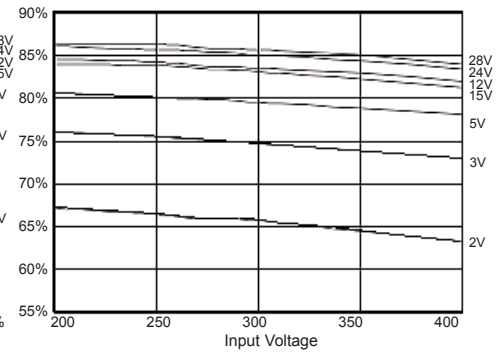
I. Input Voltage vs. Output Power



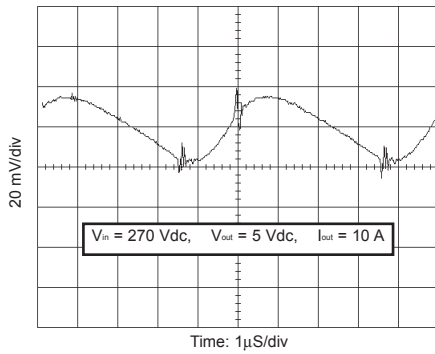
I. Efficiency vs. Load



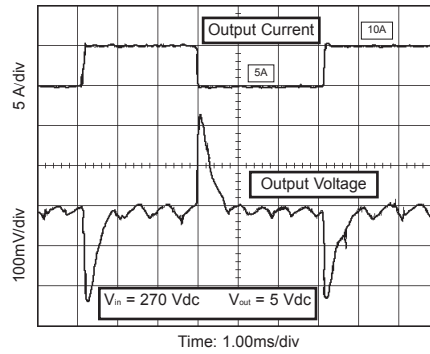
III. Efficiency vs. Line Voltage



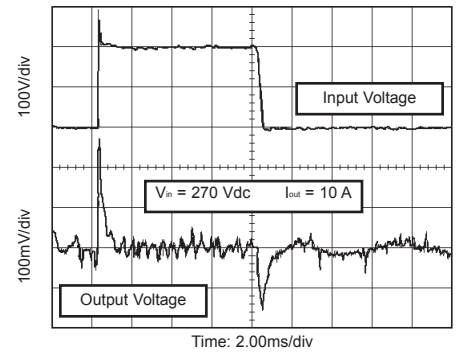
IV. Output Voltage Ripple



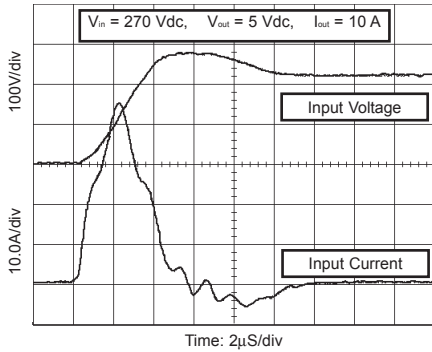
V. Load Transient Response



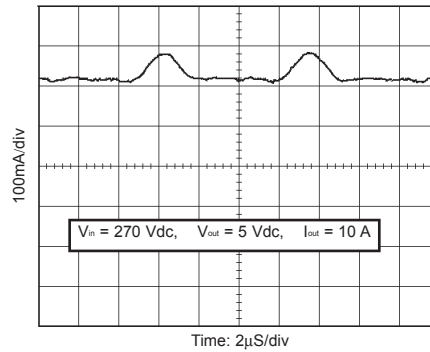
VI. Input Transient Response



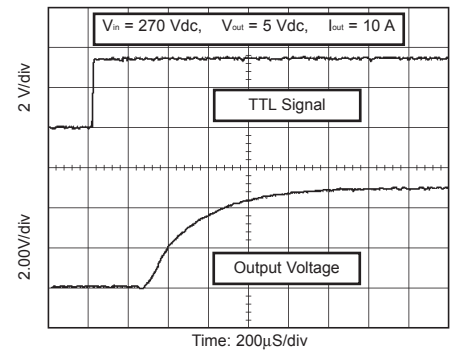
VII. Input Inrush Current



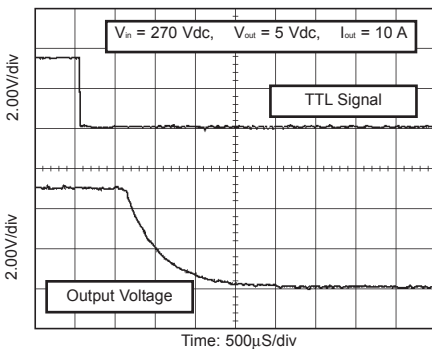
VIII. Input Current Ripple



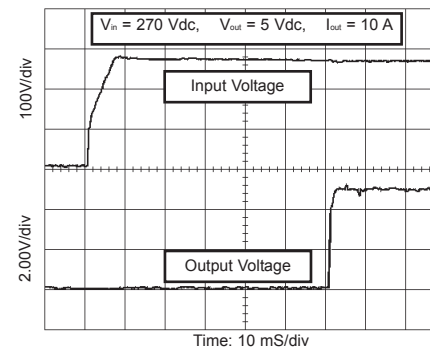
IX. TTL Turn On



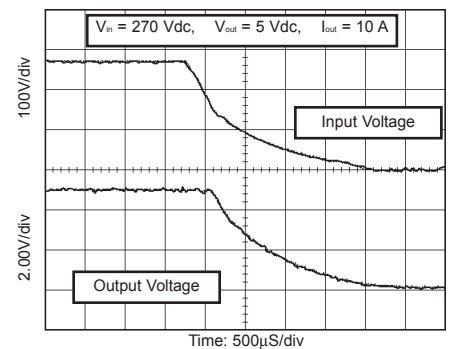
X. TTL Turn-off



XI. Turn On



XI. Turn Off / Hold-up Time



Guide to Operation

I. Electrical Description

The NH Series of power converters uses a double-ended forward converter topology. This topology dramatically reduces switching losses to yield higher converter efficiencies and lower output ripple. Advanced current mode control is utilized enabling fast transient response time. The switching frequency of the NH series is factory set greater than 180 kHz but less than 200 kHz to minimize noise and allow for simplified EMI filtering (a companion EMI module is available). Sufficient capacitance on the input and output, internal to the unit, allows for simple use and operation with no external components in most applications.

II. Mechanical Description

The NH series converters are encased in a 5 sided steel can with an aluminum baseplate to facilitate heat transfer. Their height dimension of 0.375" allows for mounting in standard 1/2 inch width circuit card racks. The NH series is available in three pin-out configurations; (A) pins out the side, for chassis mounting and maximum height reduction, (B) pins out the bottom (through the baseplate) for mounting to a metal clad PCB, and (C) pins out the top, for PCB mounting with forced air cooling (baseplate exposed to forced air). The pins are non-rigid and may be formed to suit specific mounting configurations. Care should be taken not to excessively bend or over stress the pins to avoid breakage.

The high efficiency of the NH reduces heat dissipation and minimizes heat sinking requirements i.e., maximum dissipation of the 50 watt converter operation at full load will be between 10 and 16 watts. Though this reduces heat sinking requirements, the baseplate temperature must be maintained below +100°C for military versions and +71°C for industrial versions or thermal shutdown may occur.

III. Military Specifications

The NH series is environmentally sealed and are fully qualified to the following military environmental specifications;

| Specification | Condition | Method | Procedure | Test Condition |
|----------------------|-------------------|---------------|------------------|--|
| MIL-STD-704E | Input Transient | | | Transients up to 500V for 0.1 second |
| MIL-STD-810E | Vibration | 514.4 | 1 | Up to 30gs, each axis for 1 hour |
| MIL-STD-810E | Humidity | 507.3 | 1 | 95% humidity, non-condensing for 10 days |
| MIL-STD-810E | Temp/Altitude | 520.1 | 3 | 40 hours from -55°C to +71°C |
| MIL-STD-810E | Acceleration | 513.4 | 3 | 14gs each axis |
| MIL-STD-810E | Temperature Shock | 503.3 | | -55°C to +100°C (non-operating, one hour each cycle) |
| MIL-S-901C | High Impact Shock | | | 5 foot hammer drop |

Certified test reports are available upon request.

IV. Product Features

Output Voltage Sensing

Output voltage sensing is provided for either local (at the unit) or remote (at the load) sensing. The sense feature can automatically compensate for up to a 0.5V drop in the leads to the load. **The sense pins must be connected (either local or remote) for operation or PERMANENT DAMAGE MAY OCCUR.** If remote sensing is not desired it is required to tie the sense pins locally, i.e., -sense to -output and +sense to +output.

Power Good/Built-in-test

A power good signal (pin) is provided to allow for the monitoring of the output voltage. The power good is set at +5V (referenced to the output return). If the output voltage of the converter drops below 90% of its normal set point (i.e., out of regulation), the power good pin is actively pulled low through a voltage comparator. In dual and triple configurations, power good is referenced to channel 1 output ground.

TTL (Remote on/off)

The TTL feature is used to command the NH series on and off and is referenced to the output return. When the TTL pin is left unconnected or, if a voltage between 2.4V and 5.0V is applied to the pin, the converter will remain on. When the TTL pin is pulled down below 0.8V the unit will turn off. In dual and triple configurations, TTL is referenced to channel 1 output ground.

Parallel Operation

A parallel circuit is provided to allow for parallel operation to achieve higher output power or N+1 redundancy. Parallel operation is accomplished by connecting all the parallel pins together (single pin wiring), all synchronization pins together, connecting all input power leads (+ and - leads) together, all +S pins, all -S pins, all +OUT pins, all - OUT pins, TTL and power good. Units will parallel between $\pm 10\%$ of total output power current. (See Application Notes for proper hook-up.)

Over Temperature Protection

An integral electronic over temperature shut down circuit is provided to protect the NH series from accidental over heating. If the temperature (measured at the baseplate) of the converter exceeds 5% (105°C) above the rated high operating temperature, the unit will automatically shut down. Once the temperature (measured at the baseplate) is reduced to 85%, of the rated high operating temperature, power will be automatically restored.

Output Voltage Trim

An output voltage trim pin is provided for the adjustment of the output voltage and is referenced to the output return. Using this feature the output voltage can be trimmed up to $\pm 10\%$ of nominal. To increase the output voltage of the NH series, simply attach a resistor between the trim pin and the -sense pin of the unit. Consult Application Notes for exact resistor values to achieve the desired output voltage.

Switching Frequency Synchronization

Although the NH series switches at 200kHz (180 kHz to 200 kHz) fixed frequency (clock is set at twice the switching frequency), slight variations will exist ($\pm 10\%$) between units. If desired, several NH units may be synchronized to the same switching frequency by wiring all of the sync pins together. The unit which is switching at the fastest rate will automatically become the "master" and the remaining units will adjust to switch at the same (higher) frequency. Also, the frequency of the synchronized units may be increased by injecting a higher frequency pulsed waveform into the sync pin. The sync pin is referenced to the output return

Overload/Short Circuit Protection

The output of the NH Series is protected from an accidental overload or short circuit condition of any duration. When the output load exceeds the full load capability of the supply (between 105% to 150% of the maximum rated output current) the converter switches into a "Burp-Mode" (this is where the converter is sensing the overload and is continuously turning on and off in a controlled fashion). When the overload/short circuit is removed the converter automatically returns to its normal mode of operation.

Over Voltage Protection

The NH series provides an internal “Latching” overvoltage protection circuit. Should an overvoltage condition occur the converter will shut off (output voltage will fall in accordance with Figure X). The input must be recycled to restore output.

V. Reliability

The Mean Time Between Failure (MTBF) per Mil-HBDK-217F Notice 2 calculated for the NH50SI (Industrial Version) under the operating conditions of 50°C baseplate, maximum rated output power is 416,000 hours for a ground benign environment. The MTBF for the NH50SM (military version) is 1,360,000 hours under similar conditions. Test reports for all models are available upon request.

Standard Military Grade Module Screening

Each military grade NH module under goes environmental screening based upon the parameters outlined in Mil-Std-883 and NAVMAT P4855-1. The screening and process steps consist of the following;

- 1- Stabilization Bake; +125°C for 24 hours per Mil-Std-883, M1008.2 Condition B
- 2- Voltage Isolation and Parametric Testing at 25°C
- 3- Module encapsulation and sealing
- 4- Temperature Cycling (non-operational); 10 cycles minimum, at -55°C to +125°C, 36 minute transition with a 1 hour dwell at each temperature extreme. Procedure reference Mil-Std-883, M1010, condition B and NAVMAT P4855-1.
- 5- Voltage Isolation and Parametric Testing at 25°C
- 6- Long Term Operational Burn In; 160 hours of powered operation under load. Modules are continuously cycled from +85°C to thermal shut down point (+105°C) during the 160 hours.
- 7- Voltage Isolation and Parametric Testing at 25°C
- 8- Visual Inspection

Additional testing is available including parametric testing at temperature or extended burn in time. Consult factory for more information. Additional testing or customer specific testing will require additional charges.

Application Notes

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General Application Notes

The NH family of power converters were designed as military/industrial grade stand alone DC-DC converters which can also be used as components in complex power systems. The NH Series of power converters uses a double-ended forward converter topology. This topology dramatically reduces switching losses to yield higher converter efficiencies and lower output ripple. Advanced current mode control is utilized enabling fast transient response time. The switching frequency of the NH series is fixed at 200 kHz to minimize noise and allow for simplified EMI filtering (a companion EMI module is available). Sufficient capacitance on the input and output, internal to the unit, allows for simple use and operation with no external components in most applications.

The NH units are supplied in a five-sided metal case to minimize radiated noise. The height dimension of 0.375" allows for mounting in standard 1/2-inch width circuit card racks. The NH is available in three pin-out configurations; A) pins out the side for chassis mounting and maximum height reduction, B) pins out the bottom (through the baseplate) for conduction cooling via a metal clad board, and C) pins out the top for PCB mounting with forced air cooling (baseplate exposed to forced air). The high efficiency of the NH reduces heat dissipation and minimizes heat sinking requirements i.e., maximum dissipation of the 50-watt converter will be between 8 and 16 watts. A number of protection features, as well as electrical and thermal derating of internal components allows for high reliability throughout the entire operating ranges. There are two operating ranges available, -40°C to +71°C (for industrial applications) and -55°C to +100°C (for military applications). All -55°C to +100°C units ("M" level) are fully screened in accordance with Mil-Std-833. Qualification test reports to Mil-Std-810E and Mil-Std-901C are available on request.

The most basic use of the power converter is shown in figure 1. An input fuse is always recommended to protect both the source and the power supply in the event of failures. Bus fuse type MDX or equivalent slow-blow is recommended with a current rating approximately 200% of the full load input current to the converter. Having a slow-blow type fuse will allow for the converter's inrush charge at turn-on.

The sense pins of the converter must be connected to their corresponding output pins at the load. Inherently, power converters will have some internal energy loss, which is dissipated in the form of heat through an alu-

minum mounting surface. This surface must be cooled to maintain a temperature below the maximum operating temperature.

Basic Converter Hook-up

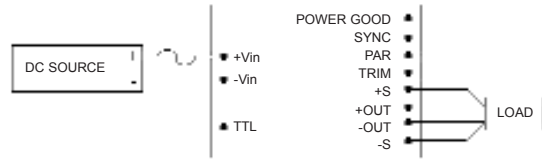


Figure 1

The NH family of power converters comes with Power Good, SYNC, PAR (Parallel Output Pin), Trim, and TTL as standard features, all referenced to the output ground.

Wire Gage & Distance to Load

If the resistance of the wire, printed circuit board runs or connectors used to connect a converter to system components is too high, excessive voltage drop will result between the converter and system components, degrading overall system performance.

For example, if the DC/DC converter in Figure 2 is a 50W unit (5 VDC @ 10 Amps) with output load regulation specified at 0.2%; the connection as shown will degrade load regulation by a factor of 10. In this example, the 4 feet of #14 AWG wire used to connect the converter output to the load, has a total line resistance of 10 mΩ (ignoring any contact resistance). For a 50W, 5VDC output converter, the drop across the wire will be 100 mV (10 A X 0.010Ω) or 2% of the output. Thus, the converter was selected for 0.2% regulation, but the power system layout achieves only 2.2%.

Converter Hook-up Losses

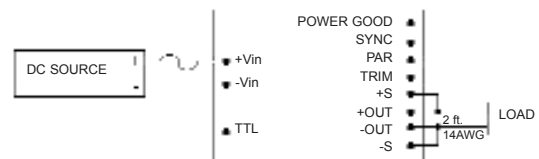


Figure 2

This can be corrected by decreasing the distance between the converter output and load. If that is not

possible, using larger diameter wire (see table 1), or PCB runs that have a larger cross sectional area and shorter length will also reduce conductor resistance. The use of the converter's remote sense capability is the ideal means of hook-up. (Figure 1)

Wire Table

| #AWG | Current Resistance mΩ/Foot | #AWG | Current Resistance mΩ/Foot |
|------|----------------------------|------|----------------------------|
| 9 | 0.792 | 21 | 12.77 |
| 10 | 0.998 | 22 | 16.20 |
| 11 | 1.261 | 23 | 20.30 |
| 12 | 1.558 | 24 | 25.67 |
| 13 | 2.001 | 25 | 32.37 |
| 14 | 2.524 | 26 | 41.02 |
| 15 | 3.181 | 27 | 51.44 |
| 16 | 4.020 | 28 | 65.31 |
| 17 | 5.054 | 29 | 81.21 |
| 18 | 6.386 | 30 | 103.7 |
| 19 | 8.046 | 31 | 130.9 |
| 20 | 10.13 | 32 | 162.0 |

Table 1

Note: High IR drops between the converter and load may cause converter parameters such as out-put voltage accuracy, trim range, etc. to appear to be out of specification. High IR drops on input lines may cause start up problems (voltage at the input pins below the input range of the converter).

Obviously, any connections made to the power distribution bus may present a problem. Poor connections (such as microcracking around solder joints) can cause serious problems such as arcing. Contact resistance must be minimized. Proper workmanship standards must be followed to insure reliable solder joints for board mount converters.

Terminal strips, spade lugs and edge connectors must be free of any corrosion, dust or dirt. If parallel lines or connections are available for routing converter output currents, they should be utilized.

Ripple & Noise

Output ripple and noise (sometimes referred to as PARD or "Periodic and Random Deviations") can be defined as unwanted variations in the output voltage of a power supply. In switching power supplies this output noise is seen as a series of pulses with a high frequency content and is therefore measured as a peak value (i.e., specified as "peak-to-peak").

Martek Power Abbott, Inc. power supplies are specified and tested in our factory with a 25 MHz or 10 Mhz bandwidth oscilloscope. Measurements taken by a

scope set at higher frequencies (i.e. 300 MHz) may produce significantly different results due to noise coupling on to the probe from sources other than the power supply.

Noise that is common to all output leads of a power converter with respect to the chasis is referred to as common mode noise. Noise that is apparent on one output lead with respect to corresponding output lead is referred to differential mode noise. Common mode noise is produced in switching action. Martek Power Abbott, Inc. typically minimizes the level of output common mode noise by incorporating line to chassis ground capacitors (on input and output leads) into the power converters. In most cases this is sufficient to minimize the level of common mode noise, however if further attenuation is required additional line to chassis ground capacitance may be added by the customer at the system level. Martek Power Abbott, Inc. noise specifications (output ripple specifications) all reference the level of differential mode noise at a given bandwidth, not the level of common mode noise. The measurement of differential mode noise is detailed in the following paragraphs.

Measurement Techniques

The length of all measurements leads (especially the ground lead) should be minimized and the sense pins should be tied to their respective outputs (+Sense to +V out). We recommend measurement as close to the supply as possible. This can be accomplished by connecting a short bus wire (generally 0.5 inches or less, making a loop at the end to place in the probe) to the negative and positive outputs on the back side of the connector mate, then place the tip of the probe on the +output and ground ring (or ground band) on the -output for a true ripple measurement. This is displayed in figure 2a;

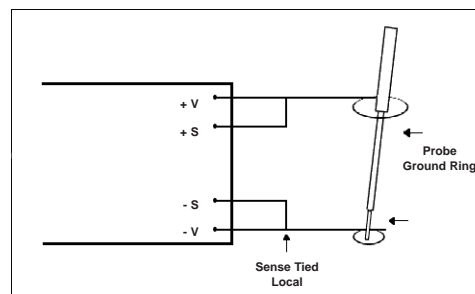


Figure 2a

Utilizing the probe ground ring (as opposed to a ground wire) will minimize the chance of noise coupling from sources other than the power supply. If this is not practical or possible then attach a 6 to 8 inch twisted pair wire to the outputs of the power supply and place a 10-

20 uF tantalum capacitor (low ESR type, with an appropriate voltage rating) across the load. This test method is shown on figure 2b.

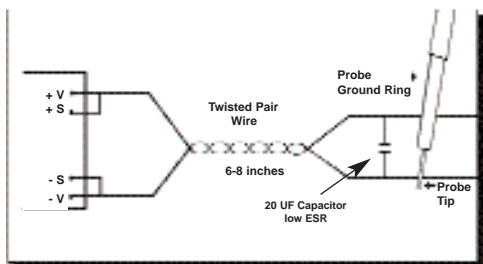


Figure 2b

This test method will enable a remote measurement and eliminate any noise that may couple on to the extended leads coming off the converter.

Ripple Reduction Techniques

In applications where the output ripple of the converter is higher than desired various techniques can be employed to reduce output ripple and noise (PARD). One method is to add additional capacitance in parallel with the output leads of the converter (low ESR type tantalums or ceramics are recommended). This should substantially reduce PARD, but be aware that excessive additional output capacitance can cause converter oscillations (see table 2 for the maximum allowable capacitance that may be added to the output leads and for typical output ripple values with this capacitance added).

| Output Voltage | Maximum Capacitance per 50W channel | Typical Vp-p@10MHZ (full load, nominal input voltage) |
|----------------|-------------------------------------|---|
| 2V | 300uF | 20mV |
| 3.3V | 300uF | 25mV |
| 5V | 300uF | 20mV |
| 5.2V | 300uF | 20mV |
| 12V | 132uF | 25mV |
| 15V | 90uF | 25mV |
| 24V | 60uF | 20mV |
| 28V | 28uF | 40mV |

Table 2

Another way to reduce PARD is to use Martek Power Abbott, Inc.'s output ripple attenuator module, SMRA (see table 3 for typical output ripple values while using the SMRA with an NH series 50 watt channel. Full specifications for the SMRA module can be found in the SM series data book).

| Output Voltage | Typical Vp-p@10MHZ (full load, nominal input voltage) |
|----------------|---|
| 2V | 10mV |
| 3.3V | 10mV |
| 5V | 10mV |
| 5.2V | 10mV |
| 12V | 10mV |
| 15V | 10mV |
| 24V | 15mV |
| 28V | SMRA not recommended with 28V channel |

Table 3

Remote Sense

Remote sense pins, +S and -S have been provided as a standard feature on NH Series converters for applications where precise load regulation is required at a distance from where the converter is physically located (See Figure 3). If remote sensing is NOT required, these pins MUST be tied to their respective output pins (+S to +OUT and -S to -OUT), otherwise, severe damage may occur to the power supply or load. If one or more of these sense pins are not connected to their respective output pins, the output(s) of the unit will not regulate to within specification and may cause a high output voltage condition.

Remote Sense - Single Output

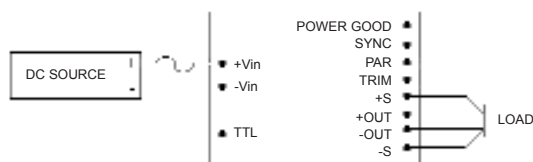


Figure 3

- DO NOT connect sense pins to any pin other than their respective output pins or permanent damage will occur.
- DO NOT connect sense pins to any load other than the same load the output pins are connected to or permanent damage may occur.

The internal remote sense circuit is designed to compensate for a maximum of 0.5V difference (0.25V in each output lead) in voltage between the load and the power converter. Longer output leads or traces are required to be of sufficient gauge or width to maintain the voltage drop across them of 0.5V maximum at rated load current.

Remote On/Off

Remote turn ON/ turn OFF feature (TTL) is a standard feature of the NH Series. This feature is especially useful in portable/mobile applications where battery power conservation is critical or in applications involving high power pulsed loads where inrush currents are high.

The NH Series employs a typical TTL open collector with positive logic control pin. The voltage level at the TTL pin is referenced with respect to the converter -

OUT pin. When the TTL circuit is pulled to less than 0.8 V ("logic 0") with respect to the - OUT pin, via either an open collector (see figure 4), or totem-pole driver, or a mechanical switch, with a 5.0mA capability, the converter shuts down. An optocoupler can also be used if the TTL signal needs to be referenced from the input side. If the TTL pin is left floating or is pulled above 2.4V up to 5.0V ('logic 1') the unit will remain on. Many more devices can be used to activate the TTL pin shutdown function, consult the factory for your specific requirements.

Remote Turn On/Off

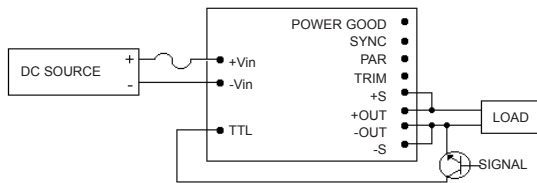


Figure 4

Output Trim

The output voltage is increased or decreased ($\pm 10\%$ Max.) by simply connecting a resistor between the trim pin and the -S voltage pin or the +S voltage pin, respectively (see figure 5).

Basic Trim Hook-Up

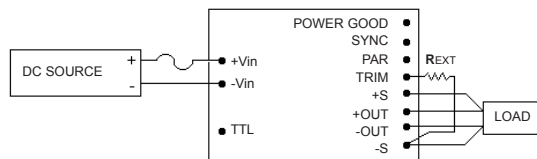


Figure 5

The value of the resistor required to trim Hi is shown in the table on page 23. The external resistor is connected between the Trim Pin and the -S Pin at the power supply. (Use standard value 1% resistor closest to the Table value).

The trim Hi value can also be found using equation below.

$$R_{EXT} = \frac{R_1 R_2 \left[\frac{R_2 V_{OUT} - R_2}{V_{OUT} (1 + \#)\%} - 1 \right] [R_2 - R_1]}{\left[\frac{R_2 V_{OUT} - R_2}{V_{OUT} (1 + \#)\%} - 1 \right] - R_2}$$

The value of the resistor required to trim Lo is shown in the table on page 24. The external resistor is connected between the Trim Pin and the +S Pin at the power supply. (Use standard value 1% resistor closest to the Table value).

RESISTANCE VALUES

| | R1 | R2 |
|---------------------|----------|---------|
| 2V _{OUT} | 60.4E+03 | 39.2E+3 |
| 3.3V _{OUT} | 36.5E+03 | 16.9E+3 |
| 5V _{OUT} | 22.6E+03 | 10.0E+3 |
| 5.2V _{OUT} | 22.6E+03 | 9.5E+3 |
| 12V _{OUT} | 9.53E+03 | 3.7E+3 |
| 15V _{OUT} | 8.87E+03 | 2.7E+3 |
| 24V _{OUT} | 5.23E+03 | 1.7E+3 |
| 28V _{OUT} | 4.42E+03 | 1.5E+3 |

Table 3

The trim LO value can also be found using equation below.

$$R_{xa} = R_2 \times V_{out} - R_2$$

$$R_{xb} = \{ [V_{out} - V_{out} \times \#]\% R_2 \} - R_2$$

$$R_{EXT} = [R_{xa} (R_1 - 1) R_{xb} - R_1 R_{xb}] \div (R_{xb} - R_{xa})$$

A potentiometer can be substituted for the resistor to achieve a more precise output voltage setting. Use the table resistor values to determine the value of the potentiometer to use.

Series Operation

The NH family of power converters may be arranged in a series operating mode to supply higher output voltages when required (see figure 6). In this configuration D1 and D2 are added to protect against the application of a negative voltage across the outputs of the power converters during power up and power down. The two (or more) units need not have the same output voltage, but the output current supplied in this configuration will be limited to the lowest maximum output current of the modules used.

Series Operation

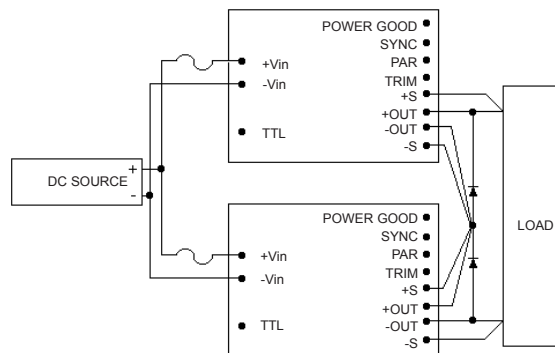


Figure 6

The Power Good pin on each power supply is referenced to its own Return. External optocouplers can be used to sum both signals together. The TTL pin on each unit is referenced to its own return. External

optocouplers can be used to sum both signals together. A Darlington type dual optocoupler is recommended. The SYNC Pins may be tied together and also tied to any 400KHz System Clock. These pins are capacitively coupled. DO NOT use the PAR Pins in this configuration. The Trim Pins may be used, but only if the external Trim Resistor is tied between the Trim Pin and Sense Pin of the same power supply.

Parallel Operation

The NH Series converter has the capability of being paralleled to drive loads of higher power. The PAR pin is supplied on the unit for this function. If parallel operation of two or more units is required, the following precautions must be followed. (NOTE: It is not recommended to parallel more than five 50 watt units or two 100 watt units. The 150 watt units may be paralleled to a maximum power level of 250 watts)

- Corresponding input and output leads or traces on each unit should be as equal in length and size as practical. The more equivalent the leads are the closer the current sharing.
- The leads connecting the PAR, SYNC and $\pm S$ pins may need to be shielded to avoid high frequency noise interference in very high power applications.
- The PAR, SYNC and $\pm S$ pins of all units should be tied together. (See Figure 7) The Power Good Pins may be tied together.
- The TTL pins should be tied together

Parallel Operation

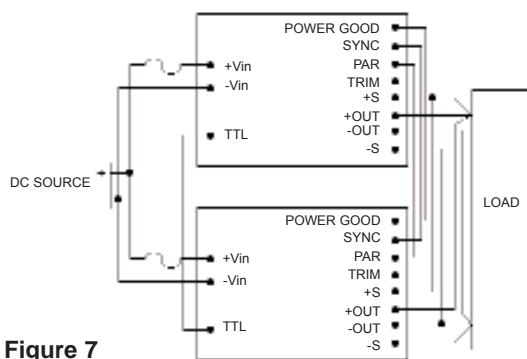


Figure 7

If trimming the output voltage is desired, first trim each output independently prior to connecting the units in parallel. Trim to within 10mV of each other under loaded conditions.

OR-ing diodes may be included in the positive output leads for true N+1 redundant systems, but are not necessary. Local sensing should be used whenever possible to minimize noise on +S and -S pins in parallel applications. In some applications, especially in those where it is difficult to keep output and input leads of equal size and length, a series resistance may be inserted in the +S lead. This will give the converter the ability to compensate for lead imbalance. Note: this will also result in a slightly higher output voltage.

Synchronization

Synchronization of multiple units to each other or to a central clock frequency is essential in noise sensitive systems. The NH Series units are capable of being synchronized to each other by tying the SYNC and -OUT pins together. This will synchronize all of the units together (see figure 8).

Synchronization of NH Units

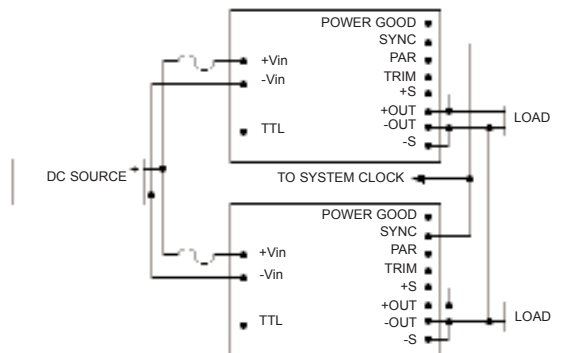


Figure 8

The NH Series converter can be tied to the central clock (see figure 8) by inputting a square wave clock signal (standard TTL levels of '0V' and '5V' are recommended) which has a frequency of 400 kHz or greater (a period of 2.5 μ S or lower) and a duty cycle of no less than 10% (a pulse width of greater than 0.25 μ S). The NH Series converter's internal synchronization circuit is triggered by the rising edge of this clock waveform. **The frequency can be increased by the external clock between the frequency range of 400-420 kHz.** The input resistance of the SYNC pin for each NH50S is 110 ohm. Higher frequencies make the unit less noise tolerant and care should be taken in how the SYNC pin line is connected between units and/or system clock. In some cases shielding the SYNC pin line will help eliminate the noise. Do not add any capacitance from the SYNC pin line to ground.

Power Good Signal

The power good signal is provided for monitoring of the output voltage. The power good is set to +5V (referenced to the output return) whenever the output of the unit is above 90% of its nominal value.

Power Good

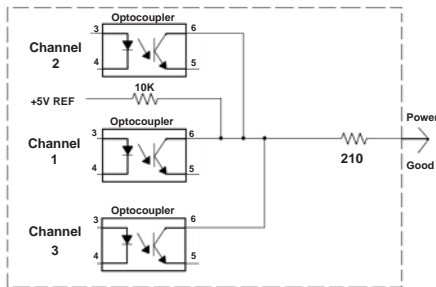


Figure 9

If the output voltage falls below this point the power good pin is actively pulled low. Also, if the output over-voltage circuit triggers due to an overvoltage condition the power good pin is actively pulled low.

See figure 9 for a schematic of the power good circuitry internal to the unit. This figure shows an optocoupler with a series resistance of 210Ω to the external power good pin. When multiple channels are utilized the

power good circuitry is connected as shown (i.e., the NH150T has three channels and therefore has three power good circuits connected together internal to the unit).

Electro Magnetic Filter (EMI) NHF150

For applications where Electromagnetic Interference is a concern, the NHF (150 watt capable), a passive input line filter, may be installed at the input of the NH series converter (see figure 10). With the NHF Mil-Std-461D, CE101 and CE102 are within compliance on the input leads. Test reports characterizing the filter for conducted emission and susceptibility are available. Filters guarantee conducted emissions (on the input leads) only. All test reports are certified by an independent testing lab.

NHF CONNECTION

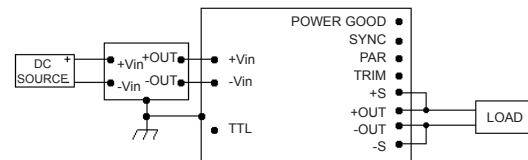
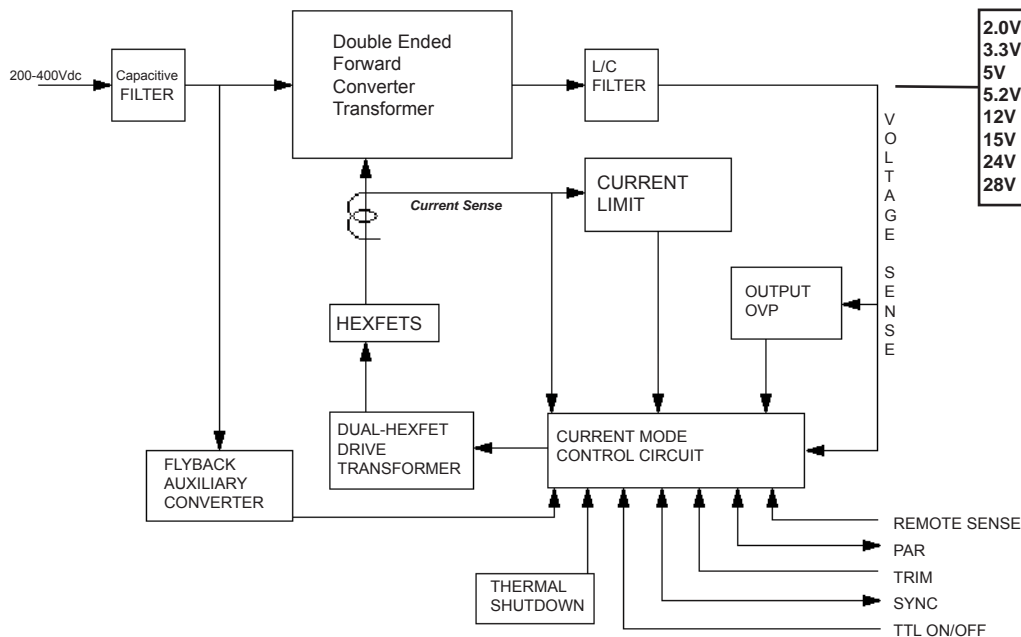


Figure 10

BLOCK DIAGRAM



Common Equations

Calculation of Input Current

Calculating the required current draw for your converter is as follows.

$$\text{Maximum Input current} = \frac{\left[\frac{\text{Output Power}}{\text{Efficiency}} \right]}{\text{Minimum Steady State Input Line}}$$

The above calculation will yield the converter's input current. For Example;

Model: NH50SM/5-C

Output Power: 50 watts

Steady State Low Line: 200 VDC

Efficiency; 78% at 200 VDC line, full load (see tables in Performance Characteristics) assuming 5% safety factor efficiency is then 73%

Minimum Steady State Input Line: 200 VDC

$$\text{Input Current} = \frac{\left[\frac{50 \text{ watts}}{0.73} \right]}{200 \text{ VDC}} \qquad \text{Input Current} = 0.342 \text{ amps}$$

The worst case steady state input current to the NH series converter operating at full load with an input of 200 VDC is 0.342 amps.

Note: it is always best to be conservative. The figures for input voltage and efficiency should always include some additional margin for error.

Power Dissipation

The calculation of the total power dissipated from the converter will be essential for thermal management of the device. Unlike other types of electronic devices DC/DC converters tend to generate a significant amount of heat. This heat is channeled (by design) to the bottom or baseplate of the module. The following equations assist when designing a suitable heat sink.

The basic equation is;

$$P_{\text{Diss}} = P_{\text{in}} - P_{\text{out}}$$

Where P_{out} is defined as the maximum load condition and P_{in} is defined as a function of P_{out} and efficiency. The equation is therefore;

$$P_{\text{Diss}} = \left[\frac{P_{\text{out}}}{\text{Efficiency}} \right] - P_{\text{out}}$$

The energy loss calculated from the above equation will be dissipated via the converter's baseplate in the form of heat. A key parameter in this equation is the converter efficiency. Efficiency will be dependent upon the line and load characteristics of the application.

The above calculation will yield the converter's power dissipation. For example;

Model: NH150SM/5-C

Output Power: 150 watts

Efficiency; 78% at 270 VDC line, 100% load (see tables in Performance Characteristics) assuming 5% safety factor efficiency is then 73%

$$P_{\text{Diss}} = \left[\frac{150}{0.73} \right] - 150 \qquad P_{\text{Diss}} = 55.48 \text{ watts}$$

The maximum power dissipated from the converter under these conditions will be 55.5 watts.

Frequently Asked Questions

Q- Can I measure output voltage without any load connected to the unit?

A- Yes, all NH modules regulate to the specified output voltage under "no load" conditions.

Q- Can I connect the input ground to the output ground or to chassis ground?

A- Yes, the input, output and chassis are isolated up 1000 VDC minimum (see specification sheet) and may be tied together in any manner.

Q- Are any additional components required to operate the NH modules?

A- No, the NH series was designed for full operational performance without the need for additional components.

Q- Are any additional components recommended to enhance operation?

A- This will depend on your application. For noise sensitive systems we would recommend the use of bypass capacitors in parallel with the output leads of the converter (low ESR type). This will reduce the effects of noise on the output lines. For applications where the power source is located a significant distance away from the converter modules it may be desirable to add bypass capacitors in parallel with the input leads. Lastly, series operation clamping diodes can be included to protect against reverse voltage conditions (see series operation note in the applications section).

Q- At the output of the converter I have a hold up capacitor in parallel with my load. Will this cause a problem?

A- It might! Though a small amount of capacitance in parallel with the output will improve (reduce) noise performance, if the capacitor is too large it may cause the converter to trip its' over load protection circuit. If this happens it will appear as a "no output" condition. If you suspect that this is happening we suggest you remove the hold up capacitor from the line. The converter will then recover immediately.

Q- The module's output voltage drops to zero at high temperature but when the unit cools down the output returns. What's causing this problem?

A- The thermal protection circuit (described in the Over Temperature Protection section in the Guide to Operation) is engaging. This circuit will activate when the baseplate exceeds its maximum operating temperature (71°C for industrial and 100°C for military versions). To verify this you must measure the temperature at the center of the baseplate with a calibrated temperature probe. The center is the converter's "hot spot" and is the monitoring point for the thermal protection circuit. Measurements taken at other locations of the device will be lower by as much as 10°C. Also, be sure that the probe is securely in contact with the converter's base minimizing contact with any other thermally conductive material while taking the measurement.

Q- How many NH modules can be used with each EMI filter?

A- The NHF EMI filters are not specified for a maximum number of units but rather a maximum output power capability. As long as the total power draw does not exceed the filter rating the filter will perform to specification.

Q- If I don't want to use some of the features of the NH converter (TRIM, TTL, PAR, SYNC or POWER GOOD) do I still have to connect the pins?

A- No, for full operating performance all that needs to be connected is the two (2) input pins, the two to six (2/6) output pins (depending on output power) and the two to six (2/6) sense pins connected to either the load or the respective +/- output pins. You **MUST** connect all output pins provided to ensure reliable operation. The remaining pins may be left open (or cut for mounting purposes).

Q- I need to use an input EMI filter in front of the converter. Do you have a suggested circuit?

A- Martek Power Abbott, Inc. offers passive EMI filters (NHF modules) that are designed to operate in conjunction with our modules to provide compliance to Mil-Std-461D, conducted emissions (CE101 and CE102) on the input leads. Many customers have successfully designed their own filter however, we advise care when doing so. Any circuit between the power source and the input to the converter has the potential to cause operational problems (such as filter/converter oscillations).

Q- What level of transient protection is the NH series capable of withstanding?

A- The converter alone can withstand a transient of 500 VDC for 100 mS as described in Mil-Std-704E.

Trim Hi Values

2V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 |
| R2 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 |
| VOUT | 2.0E+00 | 2.0E+00 | 2.1E+00 | 2.1E+00 | 2.1E+00 | 2.1E+00 | 2.1E+00 | 2.2E+00 | 2.2E+00 | 2.2E+00 |
| R TRIM (50S) | 1.09E+06 | 919.6E+03 | 592.9E+03 | 429.6E+03 | 331.6E+03 | 266.3E+03 | 219.6E+03 | 184.6E+03 | 157.4E+03 | 135.6E+03 |
| R TRIM (100S) | 949.8E+03 | 459.8E+03 | 296.5E+03 | 214.8E+03 | 165.8E+03 | 133.1E+03 | 109.8E+03 | 92.3E+03 | 78.7E+03 | 67.8E+03 |
| R TRIM (150S) | 633.2E+03 | 306.5E+03 | 197.6E+03 | 143.2E+03 | 110.5E+03 | 88.8E+03 | 73.2E+03 | 61.5E+03 | 52.5E+03 | 45.2E+03 |

3.3V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
| R1 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 |
| R2 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 |
| VOUT | 3.3E+00 | 3.4E+00 | 3.4E+00 | 3.4E+00 | 3.5E+00 | 3.5E+00 | 3.5E+00 | 3.6E+00 | 3.6E+00 | 3.6E+00 |
| R TRIM (50S) | 1.1E+06 | 552.4E+03 | 356.1E+03 | 258.0E+03 | 199.1E+03 | 159.8E+03 | 131.8E+03 | 110.7E+03 | 94.4E+03 | 81.3E+03 |
| R TRIM (100S) | 570.7E+03 | 276.2E+03 | 178.1E+03 | 129.0E+03 | 99.5E+03 | 79.9E+03 | 65.9E+03 | 55.4E+03 | 47.2E+03 | 40.6E+03 |
| R TRIM (150S) | 380.5E+03 | 184.1E+03 | 118.7E+03 | 86.0E+03 | 66.4E+03 | 53.3E+03 | 43.9E+03 | 36.9E+03 | 31.5E+03 | 27.1E+03 |

5V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|
| R1 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 |
| R2 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 |
| VOUT | 5.1E+00 | 5.1E+00 | 5.2E+00 | 5.2E+00 | 5.3E+00 | 5.3E+00 | 5.4E+00 | 5.4E+00 | 5.5E+00 | 5.5E+00 |
| R TRIM (50S) | 777.4E+03 | 377.4E+03 | 244.1E+03 | 177.4E+03 | 137.4E+03 | 110.7E+03 | 91.7E+03 | 77.4E+03 | 66.3E+03 | 57.4E+03 |
| R TRIM (100S) | 388.7E+03 | 188.7E+03 | 122.0E+03 | 88.7E+03 | 68.7E+03 | 55.4E+03 | 45.8E+03 | 38.7E+03 | 33.1E+03 | 28.7E+03 |
| R TRIM (150S) | 259.1E+03 | 125.8E+03 | 81.4E+03 | 59.1E+03 | 45.8E+03 | 36.9E+03 | 30.6E+03 | 25.8E+03 | 22.1E+03 | 19.1E+03 |

5.2V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|
| R1 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 |
| R2 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 |
| VOUT | 5.3E+00 | 5.3E+00 | 5.4E+00 | 5.4E+00 | 5.5E+00 | 5.5E+00 | 5.6E+00 | 5.6E+00 | 5.7E+00 | 5.7E+00 |
| R TRIM (50S) | 747.1E+03 | 362.3E+03 | 234.0E+03 | 169.8E+03 | 131.3E+03 | 105.7E+03 | 87.4E+03 | 73.6E+03 | 62.9E+03 | 54.4E+03 |
| R TRIM (100S) | 373.6E+03 | 181.1E+03 | 117.0E+03 | 84.9E+03 | 65.7E+03 | 52.8E+03 | 43.7E+03 | 36.8E+03 | 31.5E+03 | 27.2E+03 |
| R TRIM (150S) | 249.0E+03 | 120.8E+03 | 78.0E+03 | 56.6E+03 | 43.8E+03 | 35.2E+03 | 29.1E+03 | 24.5E+03 | 21.0E+03 | 18.1E+03 |

12V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|
| R1 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 |
| R2 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 |
| VOUT | 12.1E+00 | 12.2E+00 | 12.4E+00 | 12.5E+00 | 12.6E+00 | 12.7E+00 | 12.8E+00 | 13.0E+00 | 13.1E+00 | 13.2E+00 |
| R TRIM (50S) | 325.1E+03 | 157.8E+03 | 102.0E+03 | 74.1E+03 | 57.4E+03 | 46.2E+03 | 38.3E+03 | 32.3E+03 | 27.6E+03 | 23.9E+03 |
| R TRIM (100S) | 162.5E+03 | 78.9E+03 | 51.0E+03 | 37.1E+03 | 28.7E+03 | 23.1E+03 | 19.1E+03 | 16.1E+03 | 13.8E+03 | 12.0E+03 |
| R TRIM (150S) | 108.4E+03 | 52.6E+03 | 34.0E+03 | 24.7E+03 | 19.1E+03 | 15.4E+03 | 12.8E+03 | 10.8E+03 | 9.2E+03 | 8.0E+03 |

15V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|
| R1 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 |
| R2 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 |
| VOUT | 15.2E+00 | 15.3E+00 | 15.5E+00 | 15.6E+00 | 15.8E+00 | 15.9E+00 | 16.1E+00 | 16.2E+00 | 16.4E+00 | 16.5E+00 |
| R TRIM (50S) | 246.9E+03 | 119.0E+03 | 76.4E+03 | 55.1E+03 | 42.3E+03 | 33.8E+03 | 27.7E+03 | 23.1E+03 | 19.5E+03 | 16.7E+03 |
| R TRIM (100S) | 123.4E+03 | 59.5E+03 | 38.2E+03 | 27.5E+03 | 21.1E+03 | 16.9E+03 | 13.8E+03 | 11.5E+03 | 9.8E+03 | 8.4E+03 |
| R TRIM (150S) | 82.3E+03 | 39.7E+03 | 25.5E+03 | 18.4E+03 | 14.1E+03 | 11.3E+03 | 9.2E+03 | 7.7E+03 | 6.5E+03 | 5.6E+03 |

24V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| R1 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 |
| R2 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 |
| VOUT | 24.2E+00 | 24.5E+00 | 24.7E+00 | 25.0E+00 | 25.2E+00 | 25.4E+00 | 25.7E+00 | 25.9E+00 | 26.2E+00 | 26.4E+00 |
| R TRIM (50S) | 156.7E+03 | 75.7E+03 | 48.8E+03 | 35.3E+03 | 27.2E+03 | 21.8E+03 | 17.9E+03 | 15.0E+03 | 12.8E+03 | 11.0E+03 |
| R TRIM (100S) | 78.4E+03 | 37.9E+03 | 24.4E+03 | 17.6E+03 | 13.6E+03 | 10.9E+03 | 9.0E+03 | 7.5E+03 | 6.4E+03 | 5.5E+03 |
| R TRIM (150S) | 52.2E+03 | 25.2E+03 | 16.3E+03 | 11.8E+03 | 9.1E+03 | 7.3E+03 | 6.0E+03 | 5.0E+03 | 4.3E+03 | 3.7E+03 |

28V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| R1 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 |
| R2 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 |
| VOUT | 28.3E+00 | 28.6E+00 | 28.8E+00 | 29.1E+00 | 29.4E+00 | 29.7E+00 | 30.0E+00 | 30.2E+00 | 30.5E+00 | 30.8E+00 |
| R TRIM (50S) | 137.3E+03 | 66.5E+03 | 42.8E+03 | 31.0E+03 | 23.9E+03 | 19.2E+03 | 15.8E+03 | 13.3E+03 | 11.3E+03 | 9.8E+03 |
| R TRIM (100S) | 68.7E+03 | 33.2E+03 | 21.4E+03 | 15.5E+03 | 12.0E+03 | 9.6E+03 | 7.9E+03 | 6.6E+03 | 5.7E+03 | 4.9E+03 |
| R TRIM (150S) | 45.8E+03 | 22.2E+03 | 14.3E+03 | 10.3E+03 | 8.0E+03 | 6.4E+03 | 5.3E+03 | 4.4E+03 | 3.8E+03 | 3.3E+03 |

Trim Lo Values

2V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| R1 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 | 60.4E+03 |
| R2 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 | 39.2E+03 |
| VOUT | 2.0E+00 | 2.0E+00 | 1.9E+00 | 1.9E+00 | 1.9E+00 | 1.9E+00 | 1.9E+00 | 1.8E+00 | 1.8E+00 | 1.8E+00 |
| R TRIM (50S) | 1.9E+06 | 880.4E+03 | 553.7E+03 | 390.4E+03 | 292.4E+03 | 227.1E+03 | 180.4E+03 | 145.4E+03 | 118.2E+03 | 96.4E+03 |
| R TRIM (100S) | 930.2E+03 | 440.2E+03 | 276.9E+03 | 195.2E+03 | 146.2E+03 | 113.5E+03 | 90.2E+03 | 72.7E+03 | 59.1E+03 | 48.2E+03 |
| R TRIM (150S) | 620.1E+03 | 293.5E+03 | 184.6E+03 | 130.1E+03 | 97.5E+03 | 75.7E+03 | 60.1E+03 | 48.5E+03 | 39.4E+03 | 32.1E+03 |

3.3V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 | 36.5E+03 |
| R2 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 | 16.9E+03 |
| VOUT | 3.3E+00 | 3.2E+00 | 3.2E+00 | 3.2E+00 | 3.1E+00 | 3.1E+00 | 3.1E+00 | 3.0E+00 | 3.0E+00 | 3.0E+00 |
| R TRIM (50S) | 2.6E+06 | 1.3E+06 | 827.7E+03 | 601.9E+03 | 466.5E+03 | 376.2E+03 | 311.6E+03 | 263.3E+03 | 225.6E+03 | 195.5E+03 |
| R TRIM (100S) | 1.3E+06 | 639.6E+03 | 413.8E+03 | 301.0E+03 | 233.2E+03 | 188.1E+03 | 155.8E+03 | 131.6E+03 | 112.8E+03 | 97.8E+03 |
| R TRIM (150S) | 877.9E+03 | 426.4E+03 | 275.9E+03 | 200.6E+03 | 155.5E+03 | 125.4E+03 | 103.9E+03 | 87.8E+03 | 75.2E+03 | 65.2E+03 |

5V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 |
| R2 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 | 10.0E+03 |
| VOUT | 5.0E+00 | 4.9E+00 | 4.9E+00 | 4.8E+00 | 4.8E+00 | 4.7E+00 | 4.7E+00 | 4.6E+00 | 4.6E+00 | 4.5E+00 |
| R TRIM (50S) | 3.1E+06 | 1.5E+06 | 1.0E+06 | 737.4E+03 | 577.4E+03 | 470.7E+03 | 394.5E+03 | 337.4E+03 | 293.0E+03 | 257.4E+03 |
| R TRIM (100S) | 1.6E+06 | 768.7E+03 | 502.0E+03 | 368.7E+03 | 288.7E+03 | 235.4E+03 | 197.3E+03 | 168.7E+03 | 146.5E+03 | 128.7E+03 |
| R TRIM (150S) | 1.0E+06 | 512.5E+03 | 334.7E+03 | 245.8E+03 | 192.5E+03 | 156.9E+03 | 131.5E+03 | 112.5E+03 | 97.7E+03 | 85.8E+03 |

5.2V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 | 22.6E+03 |
| R2 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 |
| VOUT | 5.1E+00 | 5.1E+00 | 5.0E+00 | 5.0E+00 | 4.9E+00 | 4.9E+00 | 4.8E+00 | 4.8E+00 | 4.7E+00 | 4.7E+00 |
| R TRIM (50S) | 3.2E+06 | 1.6E+06 | 1.0E+06 | 745.6E+03 | 583.9E+03 | 476.2E+03 | 399.2E+03 | 341.5E+03 | 296.6E+03 | 260.7E+03 |
| R TRIM (100S) | 1.6E+06 | 776.9E+03 | 507.5E+03 | 372.8E+03 | 292.0E+03 | 238.1E+03 | 199.6E+03 | 170.7E+03 | 148.3E+03 | 130.3E+03 |
| R TRIM (150S) | 1.1E+06 | 517.9E+03 | 338.3E+03 | 248.5E+03 | 194.6E+03 | 158.7E+03 | 133.1E+03 | 113.8E+03 | 98.9E+03 | 86.9E+03 |

12V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 | 9.5E+03 |
| R2 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 | 3.7E+03 |
| VOUT | 11.9E+00 | 11.8E+00 | 11.6E+00 | 11.5E+00 | 11.4E+00 | 11.3E+00 | 11.2E+00 | 11.0E+00 | 10.9E+00 | 10.8E+00 |
| R TRIM (50S) | 3.6E+06 | 1.8E+06 | 1.2E+06 | 870.4E+03 | 686.4E+03 | 563.7E+03 | 476.1E+03 | 410.4E+03 | 359.3E+03 | 318.4E+03 |
| R TRIM (100S) | 1.8E+06 | 895.3E+03 | 588.6E+03 | 435.2E+03 | 343.2E+03 | 281.9E+03 | 238.0E+03 | 205.2E+03 | 179.6E+03 | 159.2E+03 |
| R TRIM (150S) | 1.2E+06 | 596.8E+03 | 392.4E+03 | 290.1E+03 | 228.8E+03 | 187.9E+03 | 158.7E+03 | 136.8E+03 | 119.8E+03 | 106.1E+03 |

15V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 | 8.9E+03 |
| R2 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 | 2.7E+03 |
| VOUT | 14.9E+00 | 14.7E+00 | 14.6E+00 | 14.4E+00 | 14.3E+00 | 14.1E+00 | 14.0E+00 | 13.8E+00 | 13.7E+00 | 13.5E+00 |
| R TRIM (50S) | 3.5E+06 | 1.7E+06 | 1.1E+06 | 847.8E+03 | 668.8E+03 | 549.5E+03 | 464.2E+03 | 400.3E+03 | 350.6E+03 | 310.8E+03 |
| R TRIM (100S) | 1.8E+06 | 871.5E+03 | 573.1E+03 | 423.9E+03 | 334.4E+03 | 274.7E+03 | 232.1E+03 | 200.2E+03 | 175.3E+03 | 155.4E+03 |
| R TRIM (150S) | 1.2E+06 | 581.0E+03 | 382.1E+03 | 282.6E+03 | 222.9E+03 | 183.2E+03 | 154.7E+03 | 133.4E+03 | 116.9E+03 | 103.6E+03 |

24V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 | 5.2E+03 |
| R2 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 | 1.7E+03 |
| VOUT | 23.8E+00 | 23.5E+00 | 23.3E+00 | 23.0E+00 | 22.8E+00 | 22.6E+00 | 22.3E+00 | 22.1E+00 | 21.8E+00 | 21.6E+00 |
| R TRIM (50S) | 3.7E+06 | 1.8E+06 | 1.2E+06 | 887.2E+03 | 700.9E+03 | 576.7E+03 | 488.0E+03 | 421.5E+03 | 369.8E+03 | 328.4E+03 |
| R TRIM (100S) | 1.8E+06 | 909.2E+03 | 598.8E+03 | 443.6E+03 | 350.5E+03 | 288.4E+03 | 244.0E+03 | 210.8E+03 | 184.9E+03 | 164.2E+03 |
| R TRIM (150S) | 1.2E+06 | 606.1E+03 | 399.2E+03 | 295.7E+03 | 233.6E+03 | 192.2E+03 | 162.7E+03 | 140.5E+03 | 123.3E+03 | 109.5E+03 |

28V Unit

| | 1.00% | 2.00% | 3.00% | 4.00% | 5.00% | 6.00% | 7.00% | 8.00% | 9.00% | 10.00% |
|---------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| R1 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 | 4.4E+03 |
| R2 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 | 1.5E+03 |
| VOUT | 27.7E+00 | 27.4E+00 | 27.2E+00 | 26.9E+00 | 26.6E+00 | 26.3E+00 | 26.0E+00 | 25.8E+00 | 25.5E+00 | 25.2E+00 |
| R TRIM (50S) | 3.8E+06 | 1.9E+06 | 1.2E+06 | 912.7E+03 | 721.3E+03 | 593.8E+03 | 502.6E+03 | 434.3E+03 | 381.1E+03 | 338.6E+03 |
| R TRIM (100S) | 1.9E+06 | 934.8E+03 | 615.8E+03 | 459.4E+03 | 360.7E+03 | 296.9E+03 | 251.3E+03 | 217.1E+03 | 190.6E+03 | 169.3E+03 |
| R TRIM (150S) | 1.3E+06 | 623.2E+03 | 410.5E+03 | 304.2E+03 | 240.4E+03 | 197.9E+03 | 167.5E+03 | 144.8E+03 | 127.0E+03 | 112.9E+03 |

Standard Terms & Conditions

Terms

Net 30 days from date of invoice.

Order Placement

Orders may be placed directly with Martek Power Abbott by mail, fax or telephone. Orders under \$1,000.00 on new accounts are COD or via VISA or American Express.

Taxes

All applicable VAT, Federal, State or local taxes are charged extra.

Freight

All prices listed are F.O.B. Factory, Los Angeles, California. Unless otherwise specified, shipment will be made via UPS Surface (for delivery in USA). The charges may vary by order but will generally be \$5 to \$10.00.

Insurance

Customers are liable for costs of insurance and transportation and for all import duties, taxes, licenses, clearance or other expenses required at the port of entry and destination.

Shipping and Delivery

All Martek Power Abbott power supplies are shipped complete with mounting hardware and printed instructions. Martek Power Abbott power modules are packaged for shipment per Interstate Commerce Commission Uniform Freight Classification Rules No. 40 and 41. Special military preservation and packaging is available upon request, at a modest additional cost.

Discrepancies in Delivery

It is the obligation of the customer to **notify Martek Power Abbott within ten days (of receipt)** of any obvious omissions or defects. Determination of responsibility will be made based on available information (i.e. shipping logs, carrier W/B, data, etc.)

Tax Identification Number

Martek Power Abbott's TIN number is 92-2137181.

Cage Code

Martek Power Abbott's cage code number is 15755.

Export Commodity Control Number (E.C.C.N.)

EAR99

Warranty & Repair

Warranty

Martek Power Abbott warranties each product manufactured by us, sold by us or our authorized agents, to be free from defects in material and workmanship, for the period states below for each product line. The Company shall, at its option, and as the Customer's and user's sole and exclusive remedy, issue a credit in the amount of the then applicable price of such product, or repair or replace any such product which is defective under the terms of the foregoing warranty, free of charge.

ALL OTHER EXPRESS, STATUTORY AND IMPLIED WARRANTIES, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED. IN NO EVENT WILL THE COMPANY BE LIABLE FOR ANY INDIRECT, PUNITIVE, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGE IN CONNECTION WITH OR RELATED TO THE SALE OF PRODUCTS.

I. Warranty of CB, NL, NH, NB, NW, and SM Series: CB, NL, NH, NW, NB, and SM Series are under a warranty period of three (3) years.

II. Warranty of ALL OTHER MODELS: All other models are under a warranty period of one (1) year.

Repair

I. Repair of CB, NL, NH, NB, NW, and SM Series: CB, NL, NH, NW, NB, and SM Series converters are covered under a three (3) year warranty. During this warranty period Martek Power Abbott will repair or replace (at Martek Power Abbott's discretion) all CB, NL, NH, NW, NB, and SM products found to be defective. CB, NL, NH, NW, NB, and SM Series converters which are out of warranty will not be repaired by Martek Power Abbott.

II. Repair of All other models: Martek Power Abbott will repair products covered by our warranty. To return products a Return Material Authorization (RMA) number is required. Products beyond the warranty will be repaired only after customer has authorized quoted repair charges. Any Martek Power Abbott products over seven (7) years old from date of original shipment will not be serviced or repaired.

Return Material Authorization Numbers

All returning goods must be accompanied by a Return Material Authorization (RMA) number. The RMA number must be clearly marked on the outside of the shipping carton. To receive an RMA number contact Martek Power Abbott at (310) 202-8820, ext. 4276. Please be prepared with the correct model and serial number of the returning product. For out of warranty products a company purchase order will be required for processing.

Evaluation Charges

All out of warranty products returned to Martek Power Abbott are subject to a \$50.00 evaluation charge. If the returned product is found to be in need of repair, and these repairs are authorized, the \$50.00 evaluation will be waived.

Repair Charges

Repair charges for all models are quoted per Martek Power Abbott's published repair price list. The repair charges do not include any additional processing or testing fees (i.e. ESS testing).

Shipping Instructions

All returning goods must have a Return Material Authorization (RMA) number marked on the carton. The number should be marked on a minimum of 2 sides of the carton, 3 inches (76mm) high, 6 inches (152mm) long. All goods must be shipped prepaid. Martek Power Abbott reserves the right to refuse all shipments received without a Return Material Authorization (RMA) number.



MARTEK POWER

with a worldwide network of design and manufacturing facilities, Martek Power is firmly established as a global leader in the development, manufacture and technical support of a broad range of innovative standard, semi-custom and custom power conversion products.

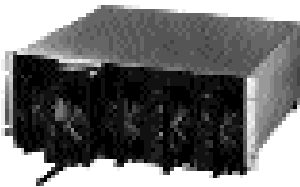
Over 1,500,000 products per year are shipped to more than 3,000 customers in markets as diverse as data processing, telecommunications, data networking, computer peripherals, aerospace, process control, military, medical and instrumentation.



With seven operating divisions located worldwide, Martek Power has the proximity to offer unparalleled local service, tailored to the needs of individual customers. Over 1,400 highly skilled employees (including 100 in R&D) are employed at ISO 9001:2000 registered manufacturing facilities in Europe, the United States, Mexico and China.



Martek Power offers one of the widest range of power conversion products in the industry. Products range from AC/DC switching power supplies, to uninterruptible power supplies, to DC/DC converter modules, to chargers. We provide cost-effective solutions to any customer power requirement whether it requires an “off-the-shelf” standard product or a semi-custom or full custom design.



Martek Power satisfies low volume “quick-turn” requirements as well as the rigorous demands of high volume OEM applications. We have the technical experience, manufacturing capacity, comprehensive product offering and total commitment to quality to be a true partner in the development of all your power system needs.

www.martekpowerabbott.com

