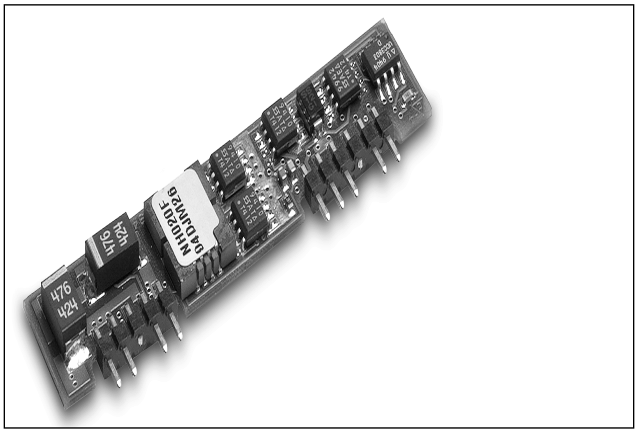
Data Sheet
April 2000

# NH020-Series Power SIPs: 5 Vdc Input; 1.5 Vdc to 3.3 Vdc Output; 20 W



**The NH020-Series Power SIPs use advanced, surface-mount technology and deliver high-quality, compact, dc-dc conversion at an economical price.**

## Applications

- Distributed power architectures
- Communication equipment
- Computer equipment

## Features

- Small size: 63.5 mm x 5.6 mm x 14.0 mm (2.50 in. x 0.22 in. x 0.55 in.)
- Nonisolated output
- Constant frequency
- High efficiency: 86% typical
- Overcurrent protection
- Remote on/off
- Output voltage adjustment
- Overtemperature protection
- *UL** 1950 Recognized, *CSA*† C22.2 No. 950-95 Certified, approved to EN60950/IEC950
- Meets FCC Class A radiated limits

## Options

- Tight tolerance output
- –40 °C operation

## Description

The NH020-Series Power SIPs are nonisolated dc-dc converters that operate over an input voltage range of 4.5 Vdc to 5.5 Vdc and provide a precisely regulated dc output. The SIPs have a maximum output current rating of 6 A at a typical full-load efficiency of 86%. Standard features include remote on/off and output voltage adjustment.

* *UL* is a registered trademark of Underwriters Laboratories, Inc.
† *CSA* is a registered trademark of Canadian Standards Association.

## Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Input Voltage (continuous) | $V_I$ | — | 7.0 | Vdc |
| Operating Ambient Temperature* | $T_{Q31}$ | –40/0† | 115 | °C |
| Storage Temperature | $T_{stg}$ | –40 | 115 | °C |
| On/Off Terminal Voltage | $V_{on/off}$ | — | 6.0 | Vdc |

* Forced convection—1.5 $ms^{-1}$ (300 lfm) minimum. Higher ambient temperatures are possible with increased airflow and/or decreased power output. See the Thermal Considerations section for more details.
† The –40 °C operation is optional. See Ordering Information section.

## Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions.

**Table 1. Input Specifications**

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Operating Input Voltage | $V_I$ | 4.5 | 5.0 | 5.5 | Vdc |
| Maximum Input Current<br>($V_I$ = 0 V to 5.5 V; $I_O = I_{O, max}$) | $I_{I, max}$ | — | — | 6.1 | A |
| Inrush Transient | $i^2t$ | — | — | 1 | $A^2s$ |
| Input Reflected-ripple Current, Peak-to-peak<br>(5 Hz to 20 MHz, 500 nH source impedance; see Figure 14.) | — | — | 625 | — | mAp-p |
| Input Ripple Rejection (120 Hz) | — | — | 60 | — | dB |

### Fusing Considerations

**CAUTION: This power SIP is not internally fused. An input line fuse must always be used.**

This power SIP can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of a sophisticated power architecture. To preserve maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a normal-blow fuse with a maximum rating of 10 A (see Safety Considerations section). To aid in the proper fuse selection for the given application, information on inrush energy and maximum dc input current is provided. Refer to the fuse manufacturer's data for further information.

## Electrical Specifications (continued)

**Table 2. Output Specifications**

| Parameter | Device or Device Suffix | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Set Point ($V_I$ = 5.0 V; $I_O = I_{O,\,max}$; $T_A$ = 25 °C) | NH020M | $V_{O,\,set}$ | 1.46 | 1.5 | 1.54 | Vdc |
| | NH020M2 | $V_{O,\,set}$ | 1.485 | 1.5 | 1.515 | Vdc |
| | NH020Y | $V_{O,\,set}$ | 1.75 | 1.8 | 1.85 | Vdc |
| | NH020Y2 | $V_{O,\,set}$ | 1.782 | 1.8 | 1.818 | Vdc |
| | NH020G | $V_{O,\,set}$ | 2.43 | 2.5 | 2.57 | Vdc |
| | NH020F | $V_{O,\,set}$ | 3.18 | 3.3 | 3.39 | Vdc |
| | NH020F2 | $V_{O,\,set}$ | 3.27 | 3.3 | 3.33 | Vdc |
| Output Voltage (Over all operating input voltage, resistive load, and temperature conditions until end of life.) | NH020M | $V_O$ | 1.43 | — | 1.57 | Vdc |
| | NH020M2 | $V_O$ | 1.455 | — | 1.545 | Vdc |
| | NH020Y | $V_O$ | 1.716 | — | 1.883 | Vdc |
| | NH020Y2 | $V_O$ | 1.745 | — | 1.855 | Vdc |
| | NH020G | $V_O$ | 2.39 | — | 2.61 | Vdc |
| | NH020F | $V_O$ | 3.16 | — | 3.44 | Vdc |
| | NH020F2 | $V_O$ | 3.24 | — | 3.36 | Vdc |
| Output Regulation: | | | | | | |
| Line ($V_I$ = 4.5 V to 5.5 V) | All | — | — | 0.1 | 0.4 | %$V_O$ |
| Load ($I_O$ = 0 to $I_{O,\,max}$) | M | — | — | 0.4 | 0.6 | %$V_O$ |
| | Y | — | — | 0.3 | 0.5 | %$V_O$ |
| | F, G | — | — | 0.1 | 0.3 | %$V_O$ |
| Temperature ($T_A$ = 0 °C to 55 °C) | All | — | — | — | 17 | mV |
| Output Ripple and Noise Voltage (See Figures 7—9 and 15.): | | | | | | |
| RMS | F, G, M | — | — | — | 25 | mVrms |
| | Y | — | — | — | 30 | mVrms |
| Peak-to-peak (5 Hz to 20 MHz) | All | — | — | — | 100 | mVp-p |
| External Load Capacitance (electrolytic) | All | — | 0 | — | 10,000 | µF |
| Output Current (Forced convection, 1.5 $ms^{-1}$ (300 lfm)) | All | $I_O$ | 0 | — | 6 | A |
| Output Current-limit Inception ($V_O$ = 90% of $V_{O,\,set}$; see Feature Descriptions section.) | All | $I_O$ | — | 350 | — | %$I_{O,\,max}$ |
| Efficiency ($V_I$ = 5.0 V; $I_O = I_{O,\,max}$; $T_A$ = 25 °C; see Figures 3—6 and 16.) | NH020M | η | 70 | 72 | — | % |
| | NH020Y | η | 73 | 75 | — | % |
| | NH020G | η | 79 | 82 | — | % |
| | NH020F | η | 84 | 86 | — | % |
| Switching Frequency | All | — | — | 500 | — | kHz |
| Dynamic Response ($\Delta I_O/\Delta t$ = 1 A/10 µs, $V_I$ = 5.0 V, $T_A$ = 25 °C; see Figures 10 and 11.): | | | | | | |
| Load Change from $I_O$ = 0% to 100% of $I_{O,\,max}$: | | | | | | |
| Peak Deviation | All | — | — | 80 | — | mV |
| Settling Time ($V_O$ < 10% peak deviation) | All | — | — | 200 | — | µs |
| Load Change from $I_O$ = 100% to 0% of $I_{O,\,max}$: | | | | | | |
| Peak Deviation | All | — | — | 80 | — | mV |
| Settling Time ($V_O$ < 10% peak deviation) | All | — | — | 200 | — | µs |

## General Specifications

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Calculated MTBF ($I_O$ = 80% of $I_{O,\ max}$; $T_A$ = 25 °C) | | 1,400,000 | | hours |
| Weight | — | — | 7 (0.25) | g (oz.) |

### Solder Ball and Cleanliness Requirements

The open frame (no case or potting) power SIP will meet the solder ball requirements per J-STD-001B. These requirements state that solder balls must neither be loose nor violate the power SIP minimum electrical spacing.

The cleanliness designator of the open frame power SIP is C00 (per J specification).

## Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions and Design Considerations sections for further information.

| Parameter | Device | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Remote On/Off Signal Interface ($V_I$ = 4.5 V to 5.5 V; open collector pnp transistor or equivalent compatible; signal referenced to GND terminal; see Figure 20 and Feature Descriptions section.): | | | | | | |
| Logic Low (ON/OFF pin open)—SIP On: | | | | | | |
| $I_{on/off}$ = 0.0 µA | All | $V_{on/off}$ | –0.7 | — | 0.3 | V |
| $V_{on/off}$ = 0.3 V | All | $I_{on/off}$ | — | — | 50 | µA |
| Logic High ($V_{on/off}$ > 2.8 V)—SIP Off: | | | | | | |
| $I_{on/off}$ = 10 mA | All | $V_{on/off}$ | — | — | 6.0 | V |
| $V_{on/off}$ = 5.5 V | All | $I_{on/off}$ | — | — | 10 | mA |
| Turn-on Time ($I_O$ = 80% of $I_{O,\ max}$; $V_O$ within ±1% of steady state; see Figures 12 and 13.) | All | — | — | 1.5 | 5.0 | ms |
| Output Voltage Set-point Adjustment Range | NH020M | $V_{trim}$ | 100 | — | 150 | $\%V_{O,\ nom}$ |
| | NH020Y | $V_{trim}$ | 100 | — | 120 | $\%V_{O,\ nom}$ |
| | NH020G | $V_{trim}$ | 90 | — | 110 | $\%V_{O,\ nom}$ |
| | NH020F | $V_{trim}$ | 84 | — | 110 | $\%V_{O,\ nom}$ |
| Overtemperature Protection (shutdown) | All | $T_{Q31}$ | — | 125 | — | °C |

## Characteristic Curves

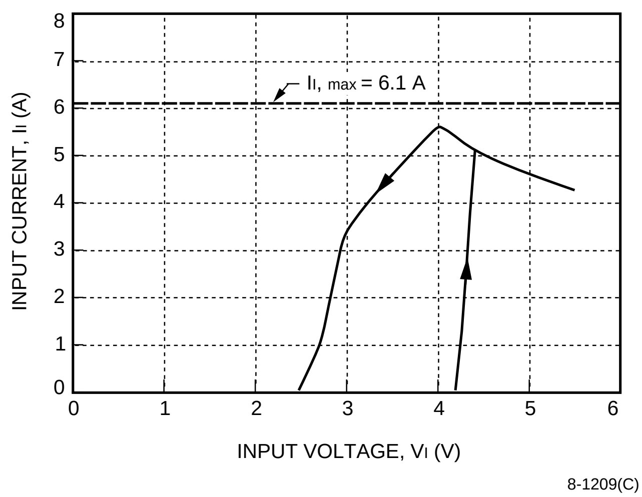



**Figure 1. Typical Input Characteristic at Room Temperature and 6 A Output**

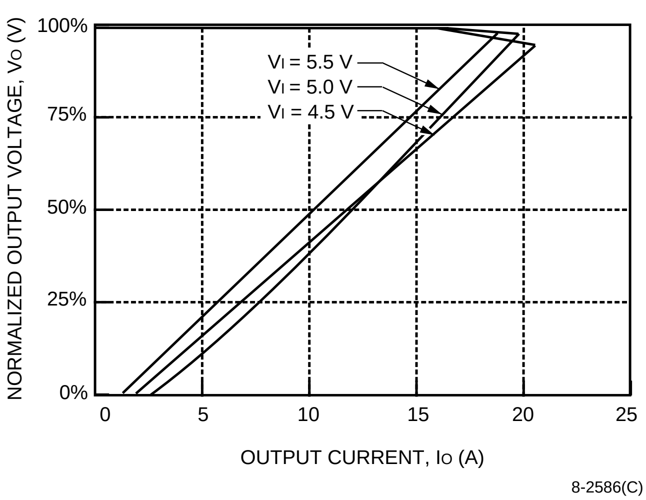



**Figure 2. Typical Output Characteristics and $T_A$ = 25 °C**

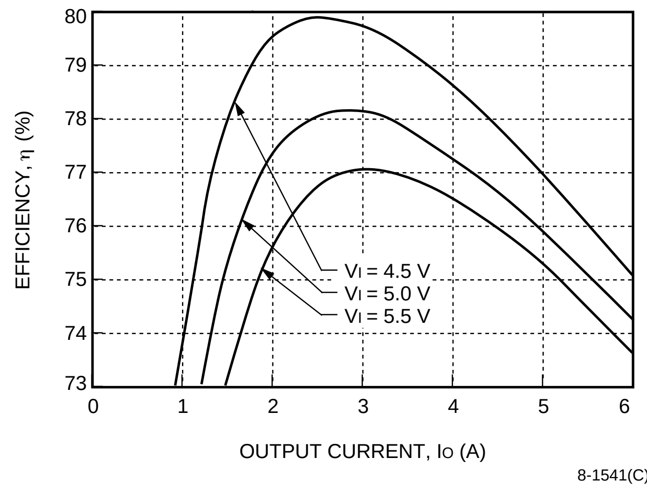



**Figure 3. NH020M Typical Efficiency at Room Temperature**

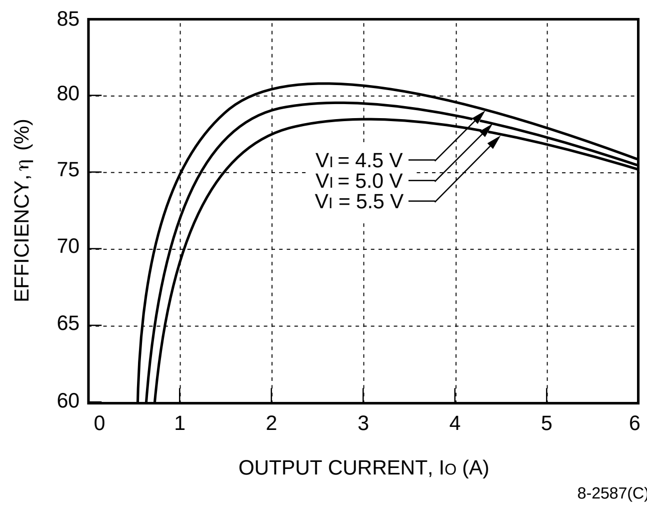



**Figure 4. NH020Y Typical Efficiency at Room Temperature**

## Characteristic Curves (continued)

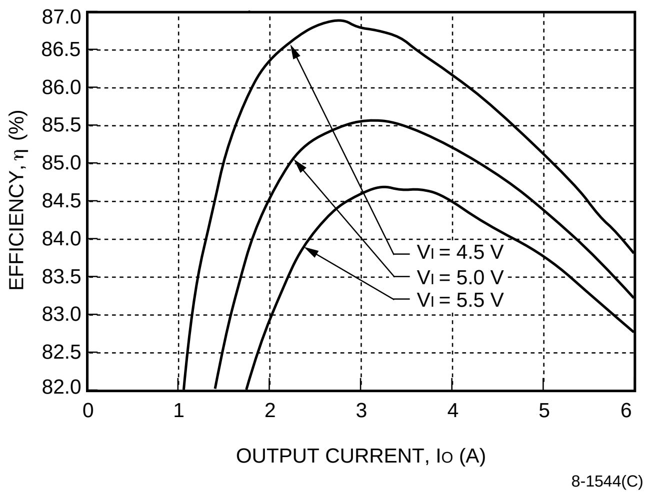



**Figure 5. NH020G Typical Efficiency at Room Temperature**

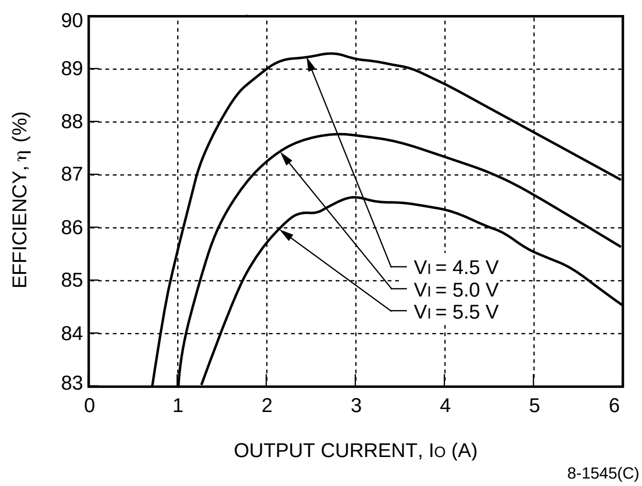



**Figure 6. NH020F Typical Efficiency at Room Temperature**

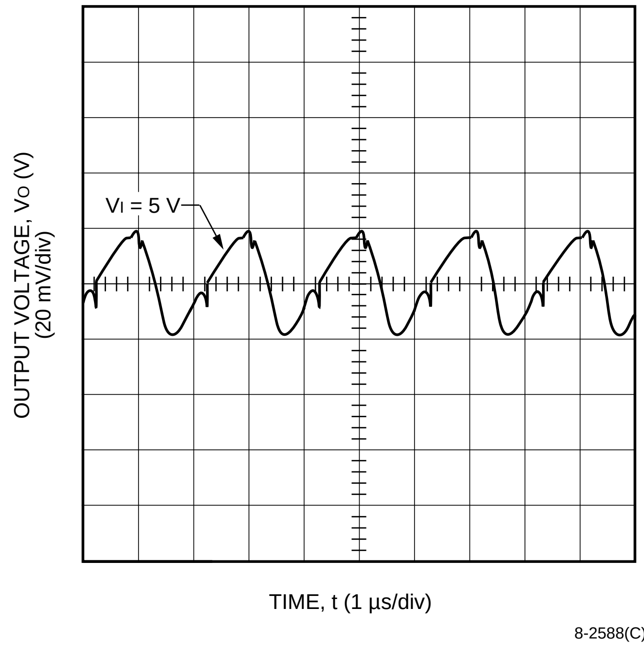



**Figure 7. NH020M Typical Output Ripple Voltage at Room Temperature and 6 A Output**

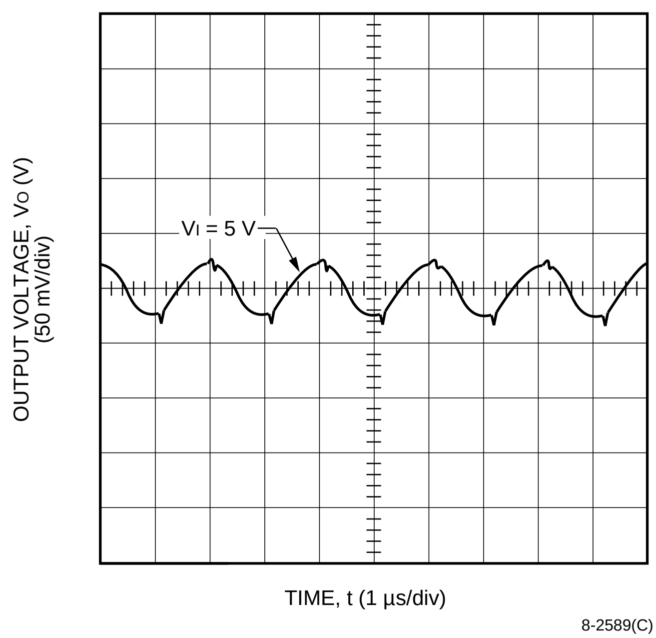



**Figure 8. NH020Y Typical Output Ripple Voltage at Room Temperature and 6 A Output**

## Characteristic Curves (continued)

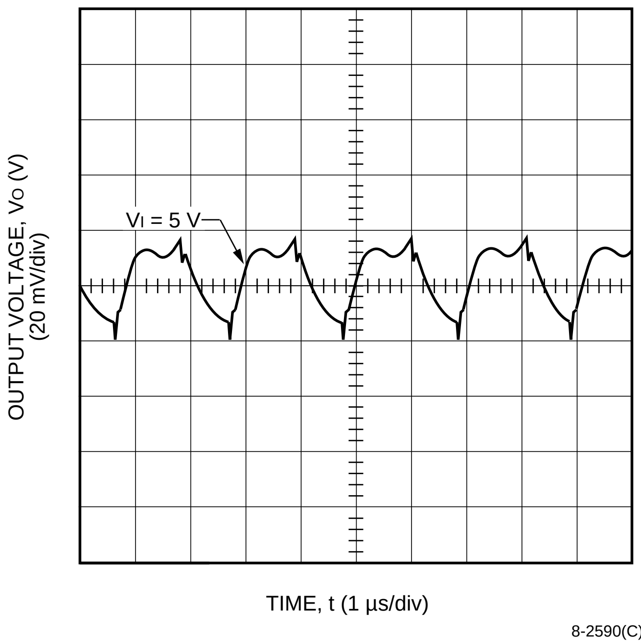



**Figure 9. NH020F, G Typical Output Ripple Voltage at Room Temperature and 6 A Output**

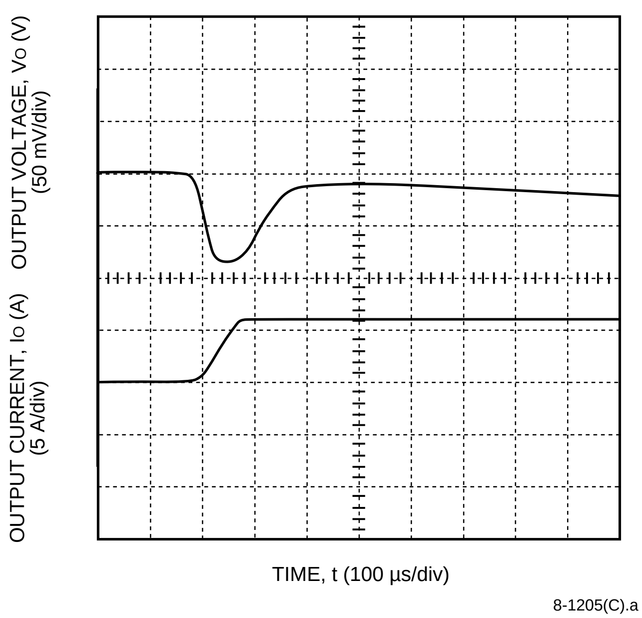



**Figure 10. Typical Transient Response to Step Load Change from 0% to 100% of $I_{O,\ max}$ at Room Temperature and 5 V Input (Waveform Averaged to Eliminate Ripple Component.)**

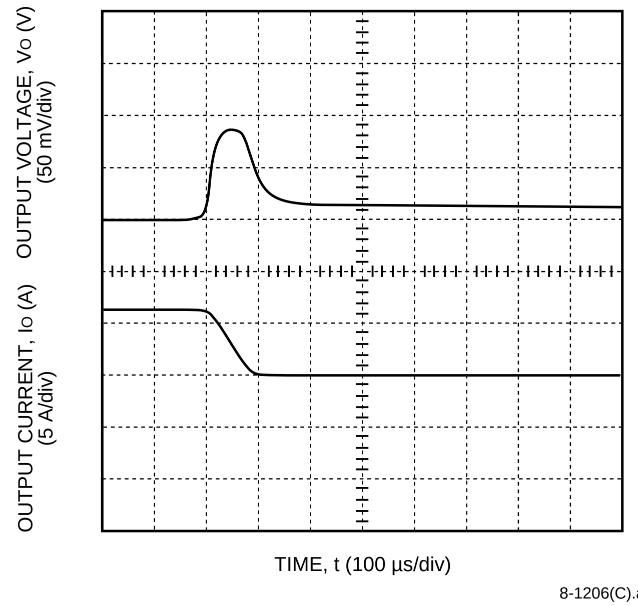



**Figure 11. Typical Transient Response to Step Load Change from 100% to 0% of $I_{O,\ max}$ at Room Temperature and 5 V Input (Waveform Averaged to Eliminate Ripple Component.)**

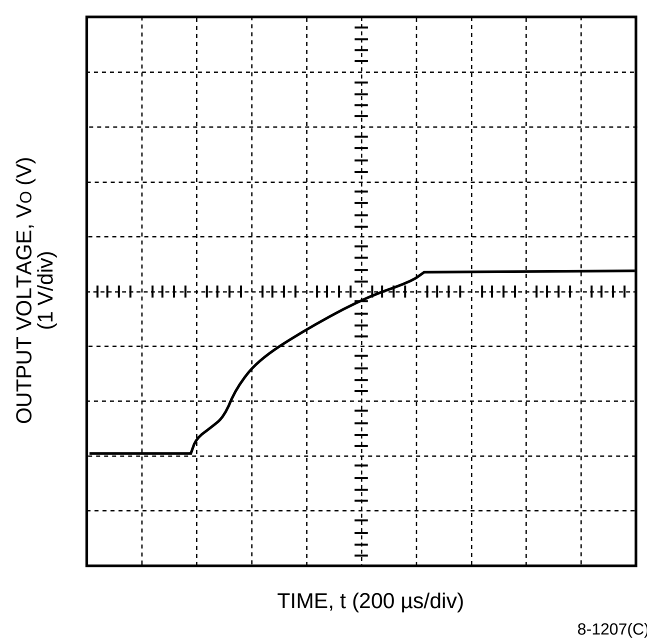



**Figure 12. Typical Start-Up Transient at Room Temperature, 5 V Input and 6 A Output**

## Characteristic Curves (continued)

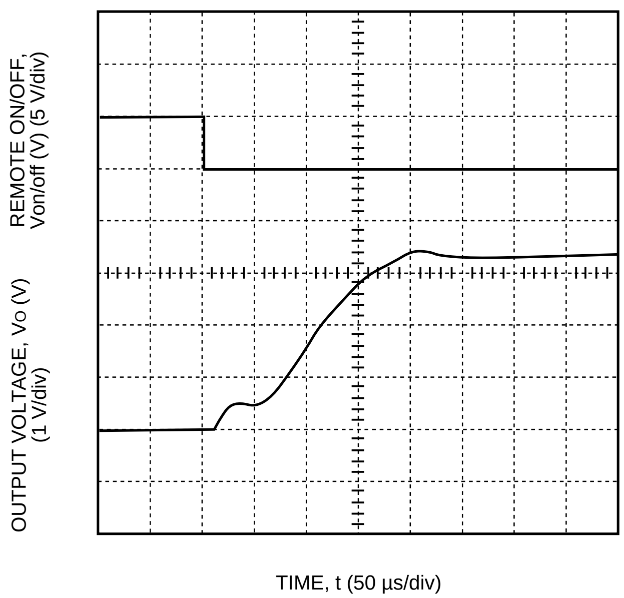
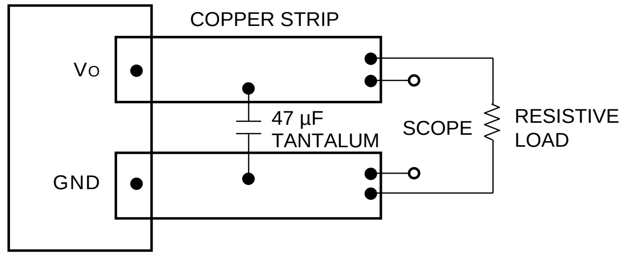


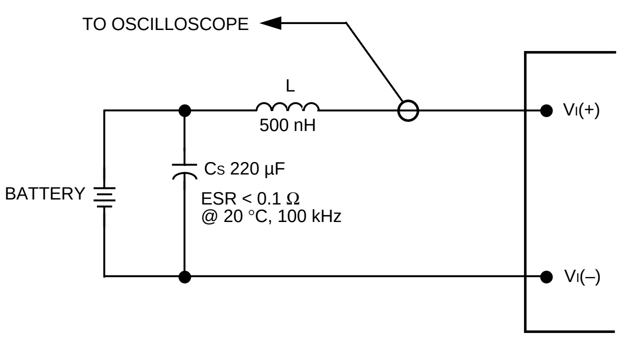

**Figure 13. Typical Start-Up Transient with Remote On/Off, at Room Temperature, 5 V Input, and 6 A Output**




Note: Use a 47 µF tantalum capacitor. Scope measurement should be made using a BNC socket. Position the load between 51 mm and 76 mm (2 in. and 3 in.) from the SIP.

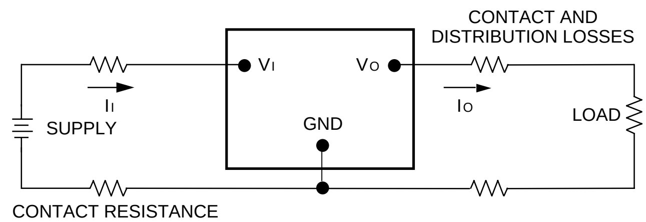
**Figure 15. Peak-to-Peak Output Noise Measurement Test Setup**

## Test Configurations




Note: Input reflected-ripple current is measured with a simulated source inductance of 500 nH. Capacitor CS offsets possible battery impedance. Current is measured at the input of the SIP.

**Figure 14. Input Reflected-Ripple Test Setup**




Note: All measurements are taken at the SIP terminals. When socketing, place Kelvin connections at SIP terminals to avoid measurement errors due to socket contact resistance.

$$\eta = \left(\frac{V_O \times I_O}{V_I \times I_I}\right) \times 100 \quad \%$$

**Figure 16. Output Voltage and Efficiency Measurement Test Setup**

# Design Considerations

## Input Source Impedance

The power SIP should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the SIP. Adding external capacitance close to the input pins of the SIP can reduce the ac impedance and ensure system stability. The minimum recommended input capacitance ($C_1$) is a 100 µF electrolytic capacitor (see Figures 17 and 19).

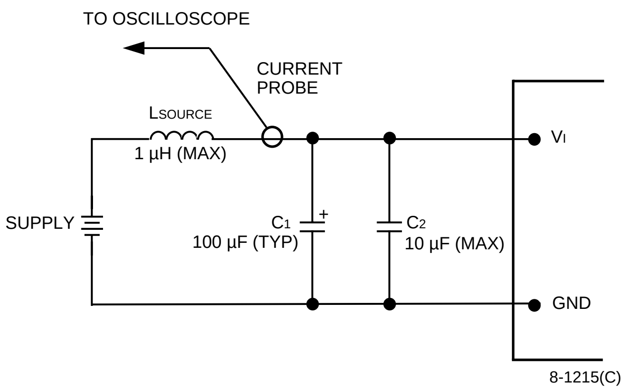



**Figure 17. Setup with External Capacitor to Reduce Input Ripple Voltage**

To reduce the amount of ripple current fed back to the input supply (input reflected-ripple current), an external input filter can be added. Up to 10 µF of ceramic capacitance ($C_2$) may be externally connected to the input of the SIP, provided the source inductance ($L_{SOURCE}$) is less than 1 µH (see Figure 17).

To further reduce the input reflected-ripple current, a filter inductor ($L_{FILTER}$) can be connected between the supply and the external input capacitors (see Figure 18).

As mentioned above, a 100 µF electrolytic capacitor ($C_1$) should be added across the input of the SIP to ensure stability of the unit. The electrolytic capacitor should be selected for ESR and RMS current ratings to ensure safe operation in the case of a fault condition. Refer to Figure 19 for the appropriate electrolytic capacitor ratings.

When using a tantalum input capacitor, take care not to exceed device power rating because of the capacitor's failure mechanism (for example, a short circuit). The filter inductor should be rated to handle the maximum power SIP input current of 6.1 Adc.

If the amount of input reflected-ripple current is unacceptable with an external L-C filter, more capacitance may be added across the input supply to form a C-L-C filter. For best results, the filter components should be mounted close to the power SIP.

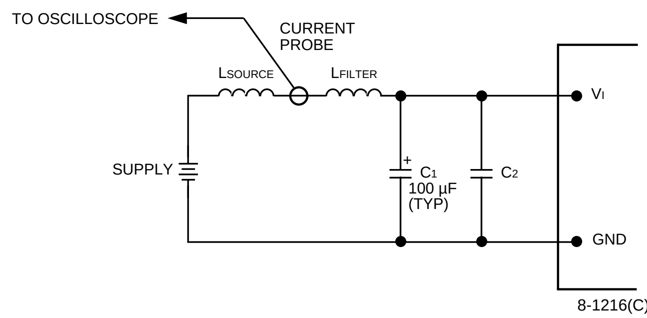



**Figure 18. Setup with External Input Filter to Reduce Input Reflected-Ripple Current and Ensure Stability**

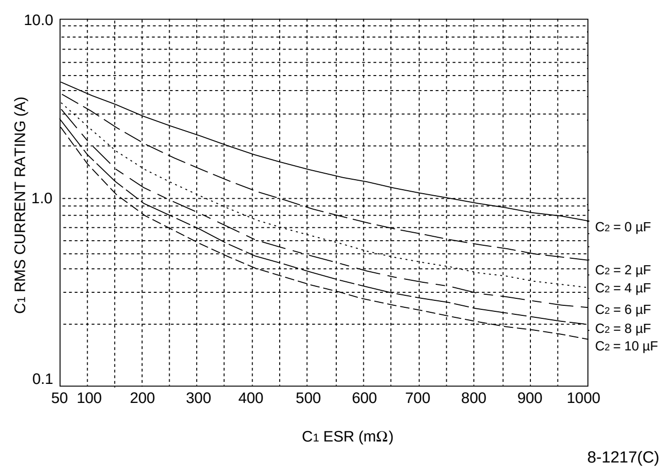



**Figure 19. Electrolytic Capacitor ESR and RMS Current Rating Data**

## Safety Considerations

For safety-agency approval of the system in which the power SIP is used, the power SIP must be installed in compliance with the spacing and separation requirements of the end-use safety agency standard, i.e., *UL* 1950, *CSA* C22.2 No. 950-95, and the EN60950/IEC950.

For the converter output to be considered meeting the requirements of safety extra-low voltage (SELV), the input must meet SELV requirements.

The power SIP has extra-low voltage (ELV) outputs when all inputs are ELV.

The input to these units is to be provided with a maximum 10 A normal-blow fuse in the ungrounded lead.

If an input electrolytic capacitor is to be used, it should be selected using the design information found in the Design Considerations section.

## Feature Descriptions

### Overcurrent Protection

To provide protection in a fault condition, the unit is equipped with internal overcurrent protection. The unit operates normally once the fault condition is removed.

Power SIP will supply up to 350% of rated current for less than 1.25 seconds before unit enters thermal shutdown.

### Remote On/Off

To turn the power SIP on and off, the user must supply a switch to control the voltage at the on/off terminal ($V_{on/off}$). The switch can be an open collector pnp transistor connected between the on/off terminal and the $V_I$ terminal or its equivalent (see Figure 20).

During a logic low when the ON/OFF pin is open, the power SIP is on and the maximum $V_{on/off}$ generated by the power SIP is 0.3 V. The maximum allowable leakage current of the switch when $V_{on/off}$ = 0.3 V and $V_I$ = 5.5 V ($V_{switch}$ = 5.2 V) is 50 µA.

During a logic high, when $V_{on/off}$ = 2.8 V to 5.5 V, the power SIP is off and the maximum $I_{on/off}$ is 10 mA. The switch should maintain a logic high while sourcing 10 mA.

If not using the remote on/off feature, leave the ON/OFF pin open.

The SIP has internal capacitance to reduce noise at the ON/OFF pin. Additional capacitance is not generally needed and may degrade the start-up characteristics of the SIP.

**CAUTION: Never ground the on/off terminal. Grounding the on/off terminal disables an important safety feature and may damage the SIP or the customer system.**

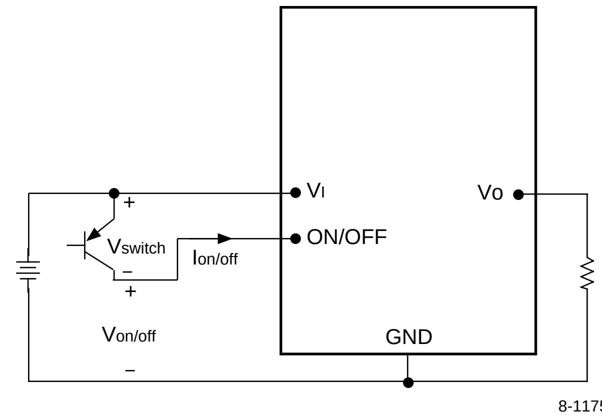



**Figure 20. Remote On/Off Implementation**

### Output Voltage Set-Point Adjustment (Trim)

Output voltage set-point adjustment allows the output voltage set point to be increased or decreased by connecting an external resistor between the TRIM pin and either the $V_O$ pin (decrease output voltage) or GND pin (increase output voltage). The trim range for the NH020F is +10%, –16%. The trim range for the NH020G is ±10% of $V_{O,\,nom}$. The trim range for SIPs that produce less than 2.5 $V_O$ is +20%, –0%.

Connecting an external resistor ($R_{trim\text{-}down}$) between the TRIM and $V_O$ pin decreases the output voltage set point as defined in the following equation.

For the F (3.3 $V_O$) SIP:

$$R_{trim\text{-}down} = \left(\frac{18.23}{V_O - V_{O,\,adj}} - 15\right)\text{k}\Omega$$

For the G (2.5 $V_O$) SIP:

$$R_{trim\text{-}down} = \left(\frac{6.975}{2.498 - V_{O,\,adj}} - 15\right)\text{k}\Omega$$

**Note:** Output voltages below 2.5 V cannot be trimmed down.

The test results for these configurations are displayed in Figures 21 and 22.

## Feature Descriptions (continued)

### Output Voltage Set-Point Adjustment (Trim) (continued)

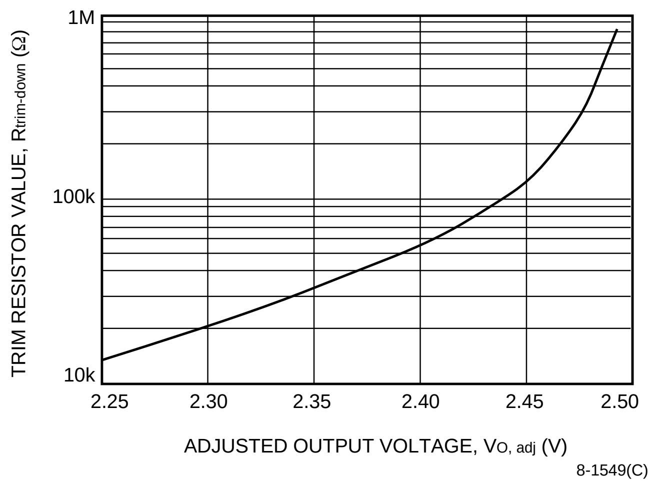



**Figure 21. NH020G $R_{trim\text{-}down}$ Test Results**

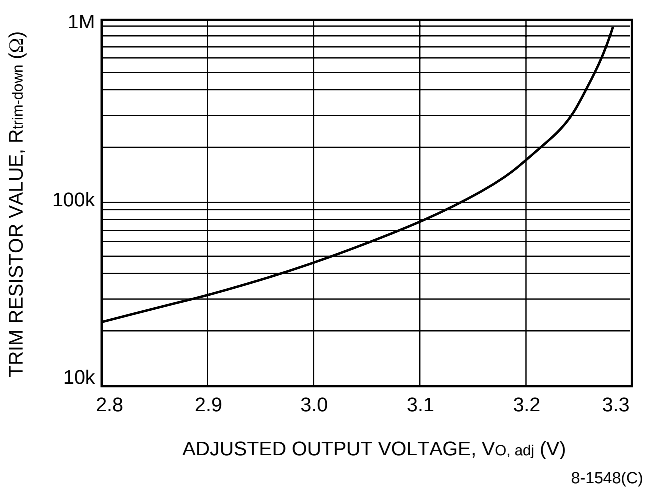



**Figure 22. NH020F $R_{trim\text{-}down}$ Test Results**

Connecting an external resistor ($R_{trim\text{-}up}$) between the TRIM and GND pins increases the output voltage set point to $V_{O,\,adj}$ as defined in the following equation:

$$R_{trim\text{-}up} = \left(\frac{28}{V_{O,\,adj} - V_O} - 1\right) k\Omega$$

The test results for this configuration are displayed in Figures 23—26.

Leave the TRIM pin open if not using that feature.

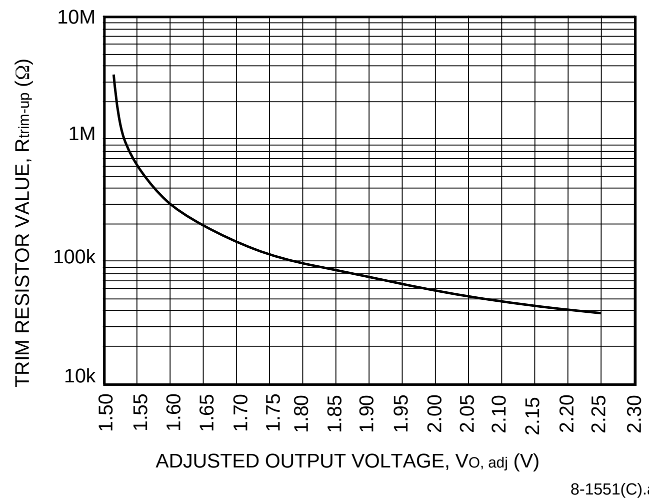



**Figure 23. NH020M $R_{trim\text{-}up}$ Test Results**

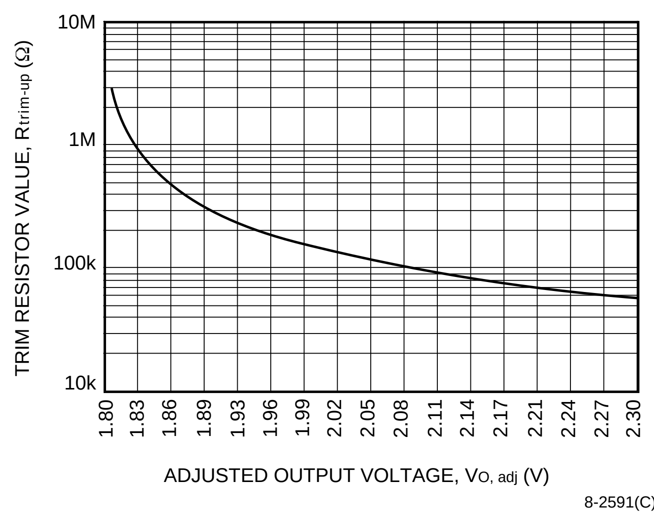



**Figure 24. NH020Y $R_{trim\text{-}up}$ Test Results**

## Feature Descriptions (continued)

### Output Voltage Set-Point Adjustment (Trim) (continued)

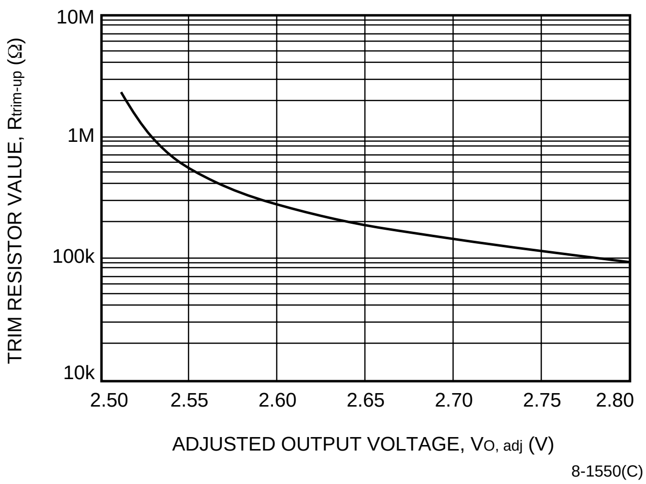



**Figure 25. NH020G $R_{trim-up}$ Test Results**

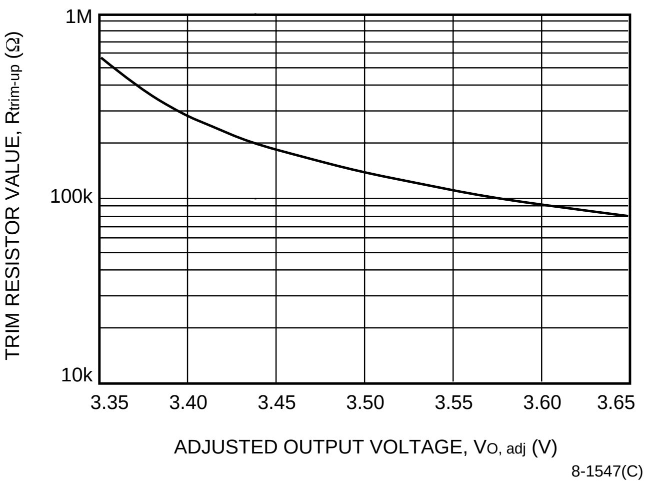



**Figure 26. NH020F $R_{trim-up}$ Test Results**

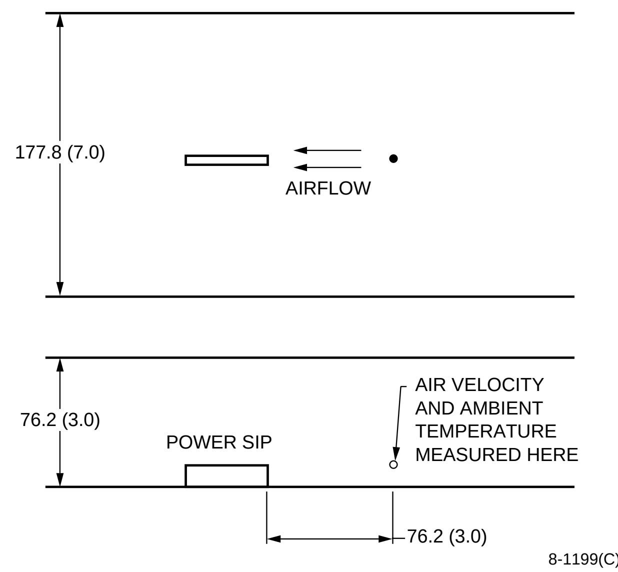
## Overtemperature Protection

To provide additional protection in a fault condition, the unit is equipped with a nonlatched thermal shutdown circuit. The shutdown circuit engages when lead 7 of Q31 (shown in Figure 28) exceeds approximately 125 °C. The unit attempts to restart when Q31 cools down and cycles on and off while the fault condition exists. Recovery from shutdown is accomplished when the cause of the overtemperature condition is removed.

## Thermal Considerations

The power SIP operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convection, and radiation to the surrounding environment.

The thermal data presented is based on measurements taken in a wind tunnel. The test setup shown in Figure 27 was used to collect data for Figure 33. Note that the airflow is parallel to the long axis of the SIP. The derating data applies to airflow along either direction of the SIP's long axis.




Note: Dimensions are in millimeters and (inches).

**Figure 27. Thermal Test Setup**

Proper cooling can be verified by measuring the power SIP's temperature at lead 7 of Q31 as shown in Figure 28.

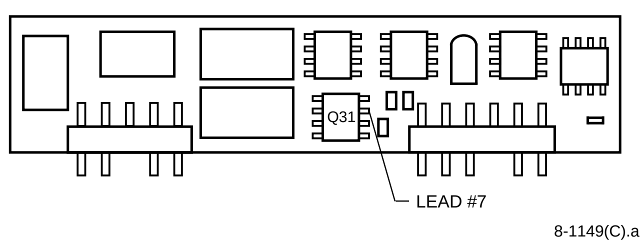



**Figure 28. Temperature Measurement Location**

The temperature at this location should not exceed 115 °C. The output power of the SIP should not exceed the rated power for the SIP as listed in the Ordering Information table.

## Thermal Considerations (continued)

### Convection Requirements for Cooling

To predict the approximate cooling needed for the SIP, determine the power dissipated as heat by the unit for the particular application. Figures 29—32 show typical heat dissipation for the SIP over a range of output currents.

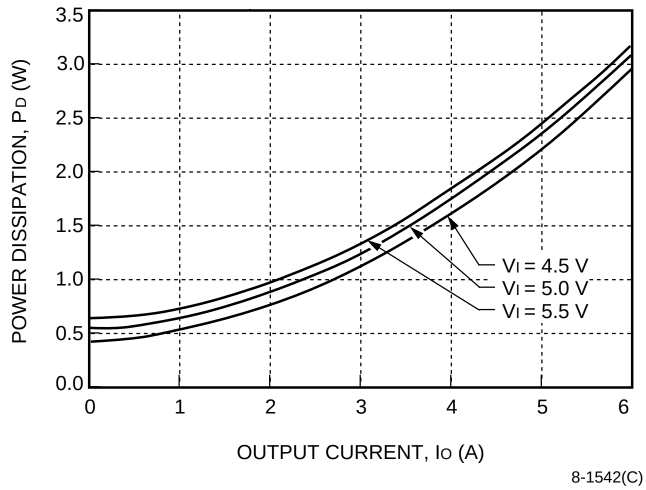



**Figure 29. NH020M Power Dissipation vs. Output Current**

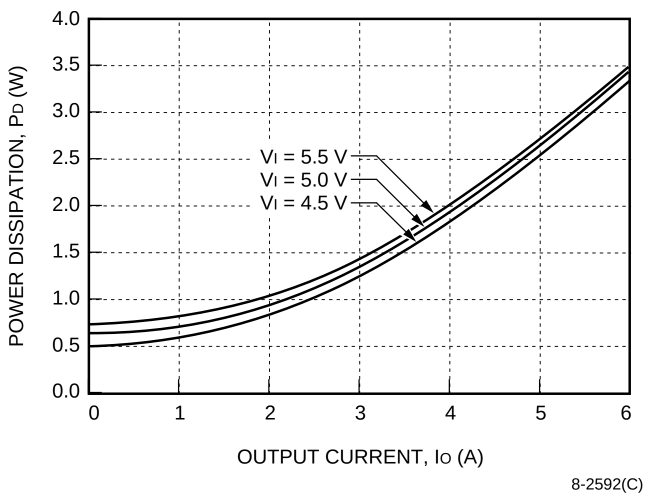



**Figure 30. NH020Y Power Dissipation vs. Output Current**

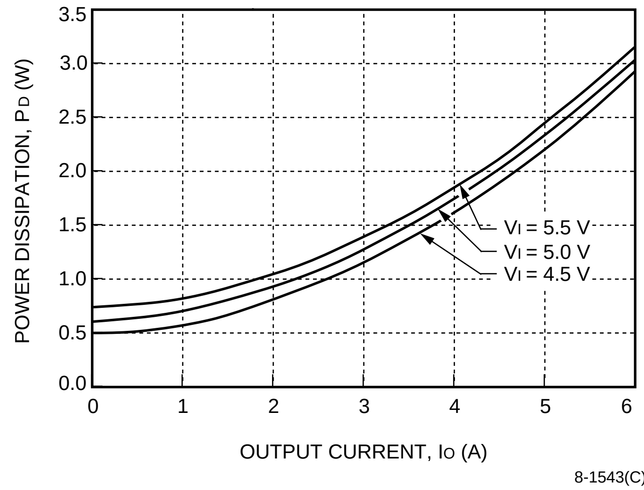



**Figure 31. NH020G Power Dissipation vs. Output Current**

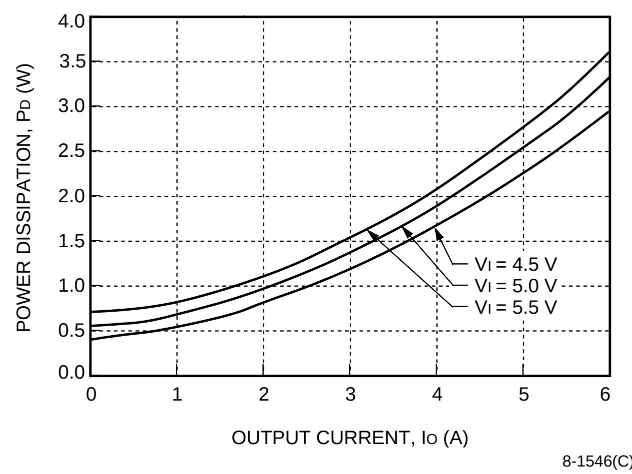



**Figure 32. NH020F Power Dissipation vs. Output Current**

## Thermal Considerations (continued)

### Convection Requirements for Cooling (continued)

With the known heat dissipation and a given local ambient temperature, the minimum airflow can be chosen from the derating curves in Figure 33.

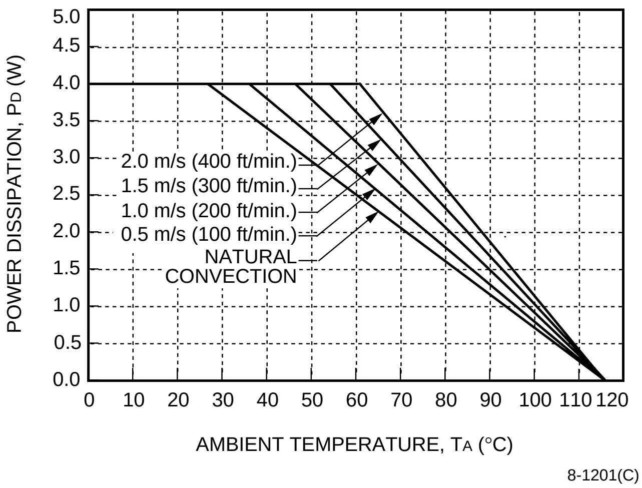



**Figure 33. Power Derating vs. Local Ambient Temperature and Air Velocity**

For example, if the unit dissipates 2.0 W of heat, the minimum airflow in an 80 °C environment is 1.0 m/s (200 ft./min.).

Keep in mind that these derating curves are approximations of the ambient temperatures and airflows required to keep the power SIP temperature below its maximum rating. Once the SIP is assembled in the actual system, the SIP's temperature should be checked as shown in Figure 28 to ensure it does not exceed 115 °C.

## Layout Considerations

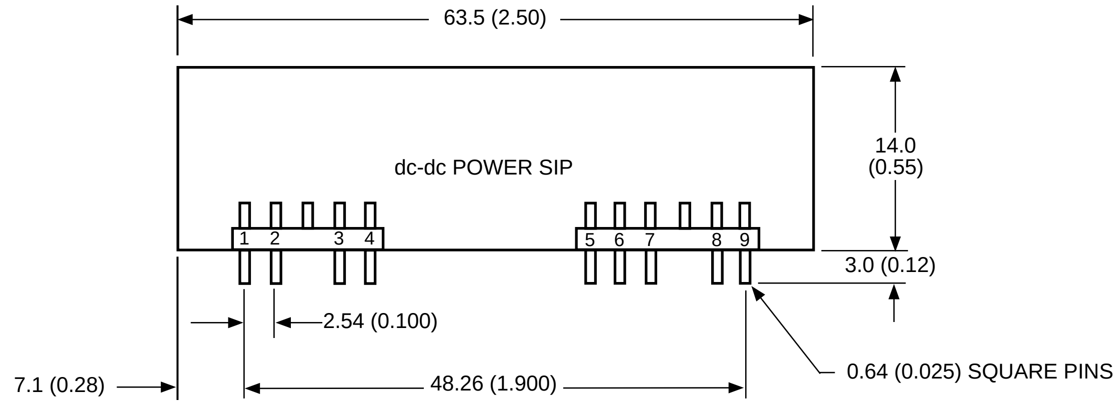
Copper paths must not be routed between pins 2 and 3 and pins 7 and 8.

## Outline Diagram

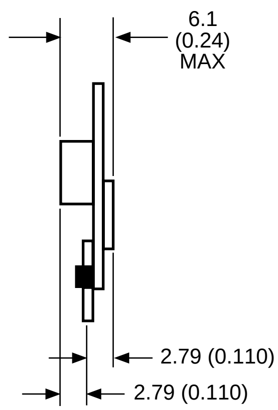
Dimensions are in millimeters and (inches).

Tolerances: x.x ± 0.5 mm (0.02 in.), x.xx ± 0.25 mm (0.010 in.).

**Front View**




**Side View**




| Pin | Function |
|---|---|
| 1 | $V_O$ |
| 2 | $V_O$ |
| 3 | $V_O$ |
| 4 | GND |
| 5 | GND |
| 6 | $V_I$ |
| 7 | $V_I$ |
| 8 | TRIM |
| 9 | ON/OFF |

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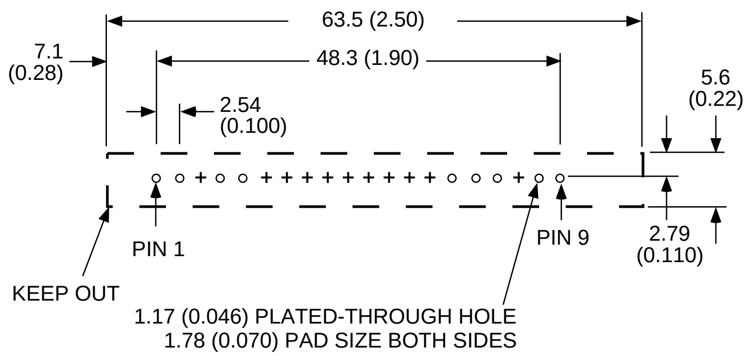
## Recommended Hole Pattern

Component-side footprint.

Dimensions are in millimeters and (inches).




8-1176(C).a

Note: No copper should be placed between pins 2 and 3 and pins 7 and 8.

## Ordering Information

Please contact your Tyco Electronics' Account Manager or Field Application Engineer for pricing and availability.

**Table 3. Device Codes**

| Input Voltage | Output Voltage | Output Power | Device Code | Comcode |
|---|---|---|---|---|
| 5 V | 1.5 V | 9 W | NH020M | 107870065 |
| 5 V | 1.8 V | 10.8 W | NH020Y | TBD |
| 5 V | 2.5 V | 15 W | NH020G | 107917114 |
| 5 V | 3.3 V | 20 W | NH020F | 107221145 |

**Table 4. Device Options**

| Option | Suffix |
|---|---|
| Tight tolerance output<br>(not available on the NH020G) | 2 |
| –40 °C operation | 5 |

## Notes

## Notes

## Notes

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DS00-127EPS (Replaces DS98-338EPS)