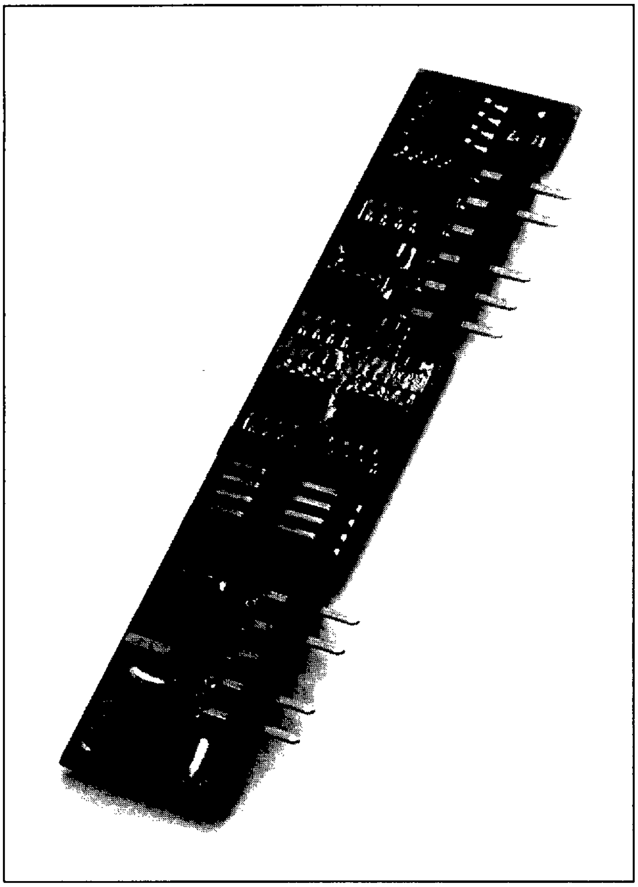
Data Sheet
January 1998

Lucent Technologies
Bell Labs Innovations

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.

Features

- Non-isolated output
- Small size: 63.5 mm x 5.6 mm x 14.0 mm (2.50 in. x 0.22 in. x 0.55 in.)
- Constant frequency
- High efficiency: 86% typical
- *UL** Recognized, *CSA*† Certified
- Meets FCC and VDE Class A radiated limits
- Remote on/off
- Output voltage adjustment
- Overcurrent protection
- Thermal shutdown

Applications

- Distributed power architectures
- Servers
- Workstations
- Desktop computers

Options

- Tight tolerance output

Description

The NH020 Series Power SIPs are non-isolated 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 trim.

* *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	V
On/Off Terminal Voltage	$V_{on/off}$	—	6.0	Vdc
Operating Ambient Temperature*	T_A	0	55	°C
Storage Temperature	T_{stg}	–40	115	°C

* Forced convection—300 lfm minimum. Higher ambient temperatures are possible with increased airflow and/or decreased power output. See the Thermal Considerations section for more details.

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 (V_I = 0 V to 5.5 V; $I_O = I_{O,\,max}$)	$I_{I,\,max}$	—	—	6.1	A
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 500 nH source impedance; see Figure 12.)	—	—	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. 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. For maximum fuse rating, see the Safety Considerations section.

Electrical Specifications (continued)

Table 2. Output Specifications

Parameter	Device	Symbol	Min	Typ	Max	Unit
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
	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 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
	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 Regulation:						
Line (V_I = 4.5 V to 5.5 V)	All	—	—	0.1	0.3	%
Load (I_O = 0 to $I_{O,\,max}$)	All	—	—	0.1	0.3	%
Temperature (T_A = 0 °C to 55 °C)	All	—	—	—	17	mV
Output Ripple and Noise (See Figure 4 and Figure 13.):						
RMS	All	—	—	—	25	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, 300 lfm)	All	I_O	0	—	6.00	A
Output Current-limit Inception (V_O = 90% of $V_{O,\,set}$; see Figure 2 and Feature Descriptions section.)	All	I_O	110	—	250	$\%I_{O,\,max}$
Efficiency (V_I = 5.0 V; $I_O = I_{O,\,max}$; T_A = 25 °C; see Figure 7 and Figure 14.)	NH020M	η	70	72	—	%
	NH020M2	η	70	72	—	%
	NH020G	η	79	82	—	%
	NH020F	η	84	86	—	%
	NH020F2	η	84	86	—	%
Dynamic Response ($\Delta I_O/\Delta t$ = 1 A/10 µs, V_I = 5.0 V, T_A = 25 °C; see Figure 8 and Figure 9.):						
Load Change from I_O = 0% to 100% of $I_{O,\,max}$:						
Peak Deviation	All	—	—	20	—	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	—	—	25	—	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		hr
Weight	—	—	7 (0.25)	g (oz.)

Solder Ball and Cleanliness Requirements

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

The cleanliness designator of the open frame power module 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 18 and Feature Descriptions section.):						
Logic Low (ON/OFF pin open)—Module On:						
$I_{on/off}$ = 0.0 µA	All	$V_{on/off}$	0	—	0.3	V
$V_{on/off}$ = 0.3 V	All	$I_{on/off}$	—	—	50	µA
Logic High ($V_{on/off}$ > 2.8 V)—Module 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 Figure 10 and Figure 11.)	All	—	—	1.5	5.0	ms
Output Voltage Set-point Adjustment Range (trim)	NH020M	—	100	—	120	$\%V_{O,\,nom}$
	NH020M2	—	100	—	120	$\%V_{O,\,nom}$
	NH020G	—	90	—	110	$\%V_{O,\,nom}$
	NH020F	—	84	—	110	$\%V_{O,\,nom}$
	NH020F2	—	84	—	110	$\%V_{O,\,nom}$

Characteristic Curves

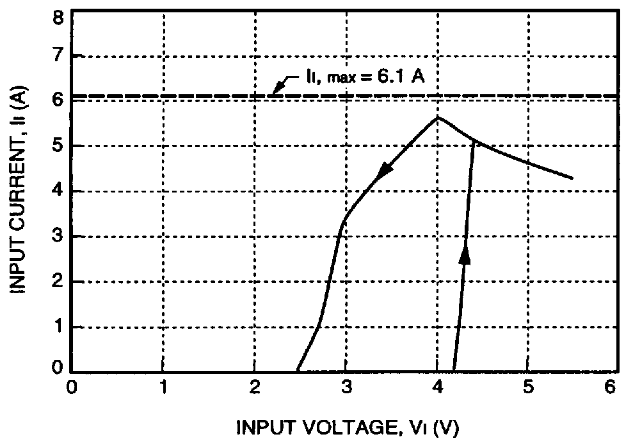


Figure 1. Typical Input Characteristic at Room Temperature and 6 A Output

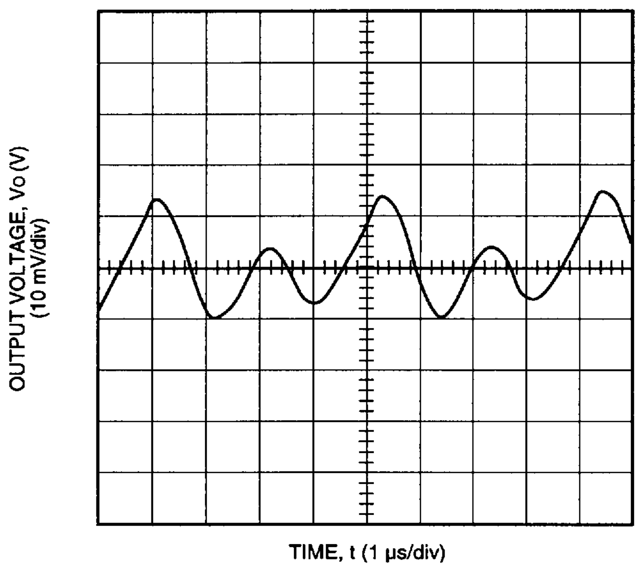


Figure 2. NH020M and NH020M2 Typical Output Ripple Voltage at Room Temperature, 5 V Input, and 6 A Output

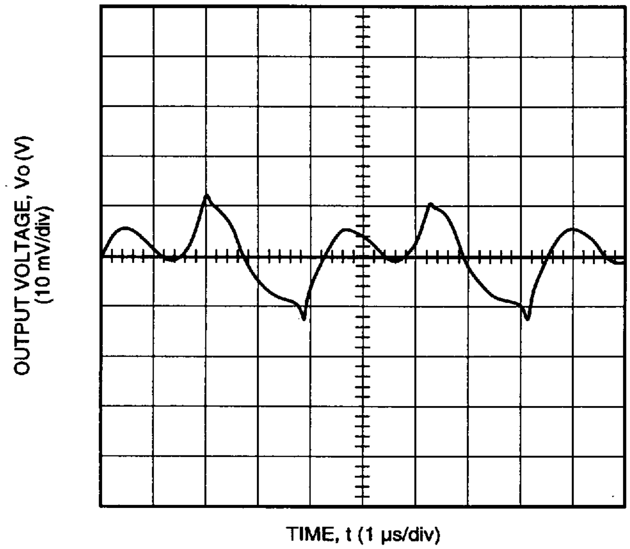


Figure 3. NH020G Typical Output Ripple Voltage at Room Temperature, 5 V Input, and 6 A Output

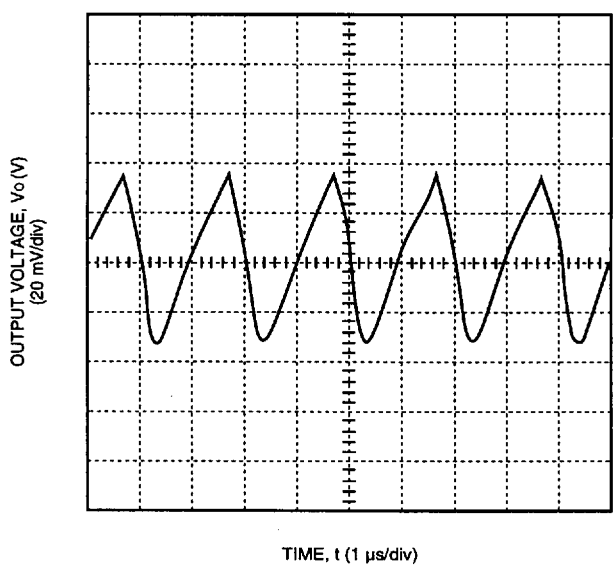


Figure 4. NH020F and NH020F2 Typical Output Ripple Voltage at Room Temperature, 5 V Input, and 6 A Output

Characteristic Curves (continued)

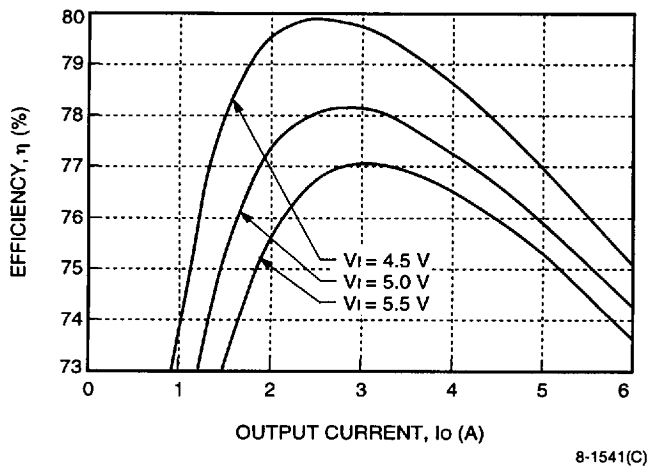


Figure 5. NH020M and NH020M2 Typical Efficiency at Room Temperature and 5 V Input

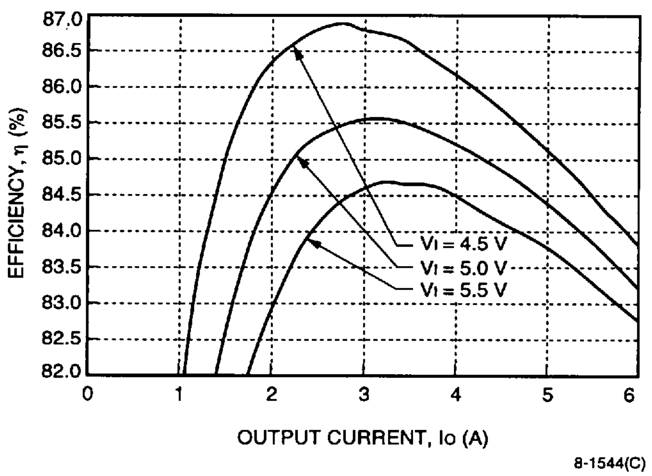


Figure 6. NH020G Typical Efficiency at Room Temperature and 5 V Input

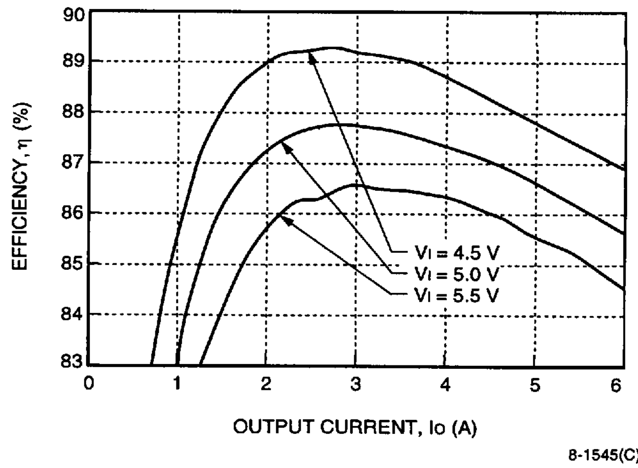


Figure 7. NH020F and NH020F2 Typical Efficiency at Room Temperature and 5 V Input

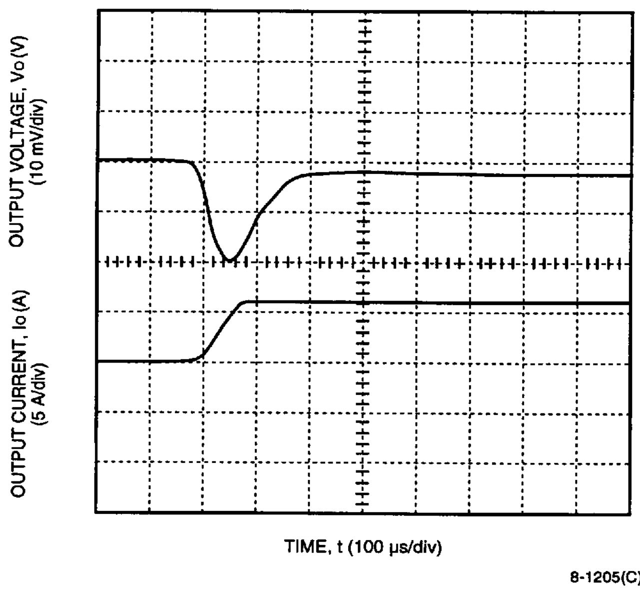


Figure 8. Typical Transient Response to Step Load Change from 0% to 100% of Full Load at Room Temperature and 5 V Input (Waveform Averaged to Eliminate Ripple Component.)

Characteristic Curves (continued)

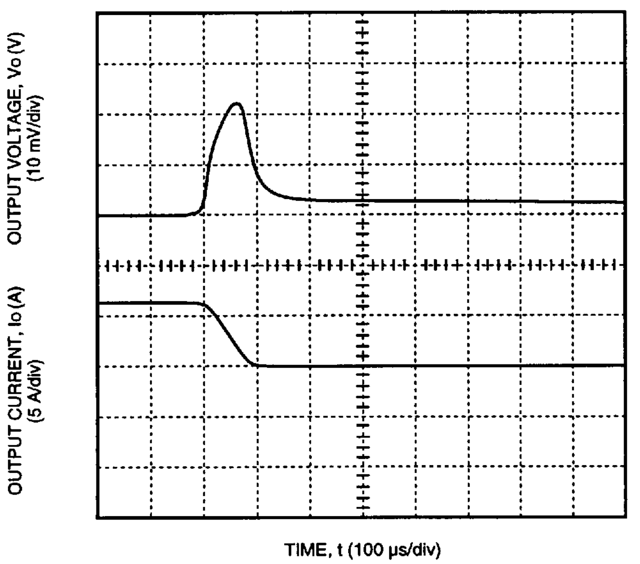


Figure 9. Typical Transient Response to Step Load Change from 100% to 0% of Full Load at Room Temperature and 5 V Input (Waveform Averaged to Eliminate Ripple Component.)

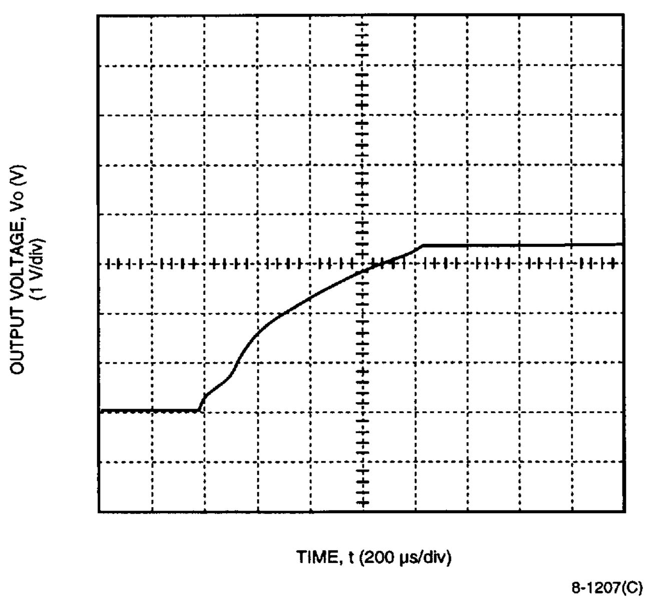


Figure 10. Typical Start-Up Transient at Room Temperature, 5 V Input and 6 A Output

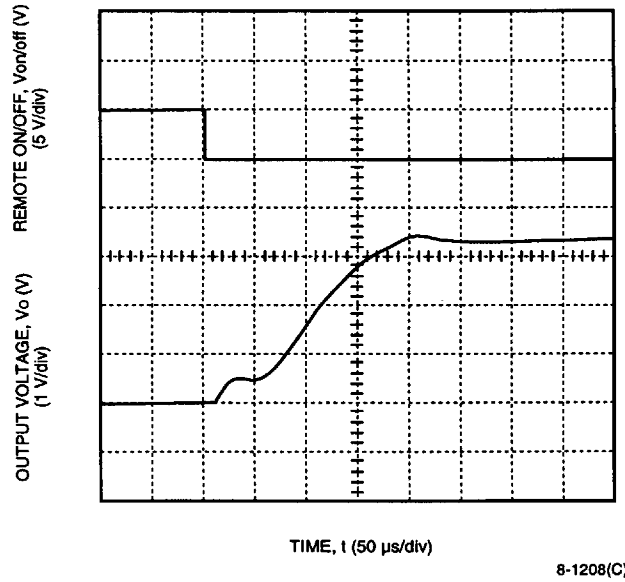
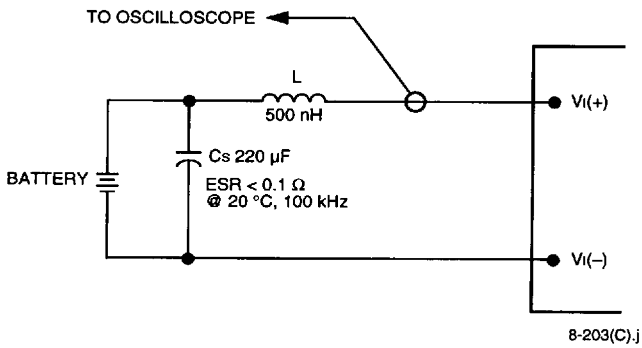


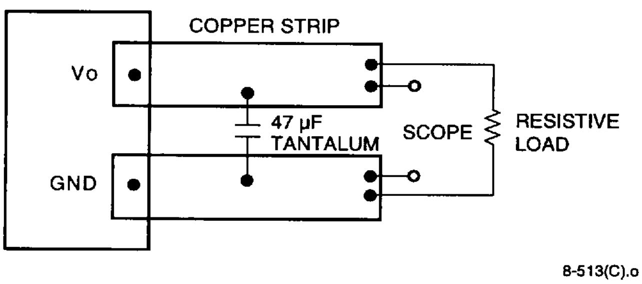
Figure 11. Typical Start-Up Transient with Remote On/Off, at Room Temperature, 5 V Input, and 6 A Output

Test Configurations



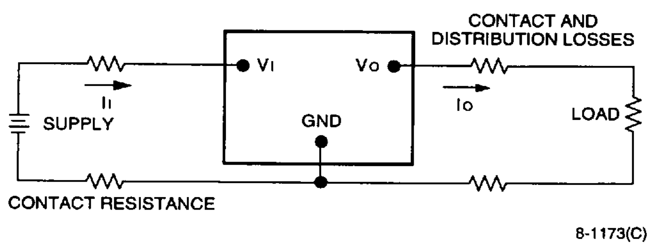
Note: Input reflected-ripple current is measured with a simulated source inductance of 500 nH. Capacitor Cs offsets possible battery impedance. Current is measured at the input of the module.

Figure 12. Input Reflected-Ripple Test Setup



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 module.

Figure 13. Peak-to-Peak Output Noise Measurement 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.

$$\eta = \frac{V_O \times I_O}{V_I \times I_I}$$

Figure 14. Single-Output Voltage and Efficiency Measurement Test Setup

Design Considerations

Safety Considerations

For safety-agency approval of the system in which the power module is used, the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standard, i.e., *UL*-1950, *CSA* 22.2-950, and EN60950.

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

If the input meets extra-low voltage (ELV) requirements, then the converter's output is considered 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 following section.

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 module can reduce the ac impedance and ensure system stability. The minimum recommended input capacitance (C_1) is a 100 µF electrolytic capacitor (see Figure 15 and Figure 17).

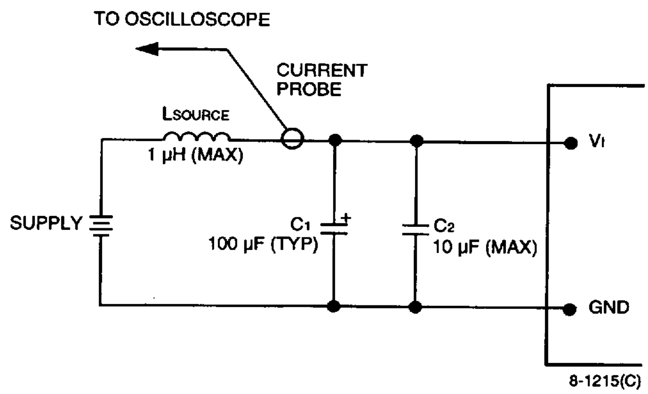


Figure 15. Setup with External Capacitor to Reduce Input Ripple Voltage

Design Considerations (continued)

Input Source Impedance (continued)

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 15).

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 16).

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 17 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.

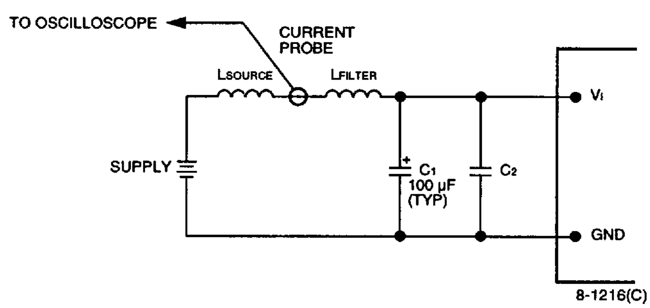


Figure 16. Setup with External Input Filter to Reduce Input Reflected-Ripple Current and Ensure Stability

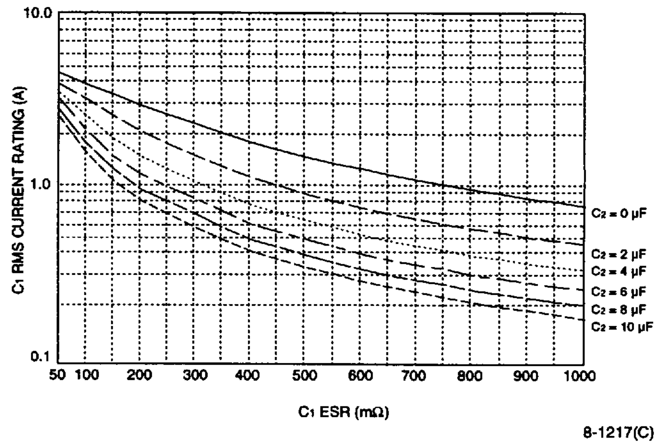


Figure 17. Electrolytic Capacitor ESR and RMS Current Rating Data

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.

Thermal Shutdown

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 25) 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.

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 18).

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 module 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.

Feature Descriptions (continued)

Remote On/Off (continued)

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.

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

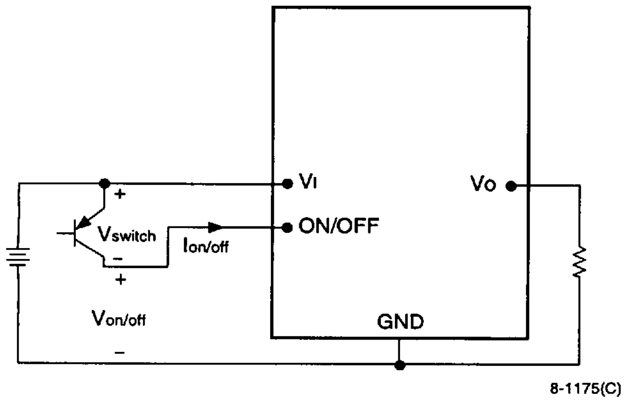


Figure 18. Remote On/Off Implementation

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 Vo 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 modules that produce less than 2.5 V_{OUT} is +20%, –0%.

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

For the F (3.3 V_{OUT}) module:

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

For the G (2.5 V_{OUT}) module:

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

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

The test results for these configurations are displayed in Figure 19 and in Figure 21.

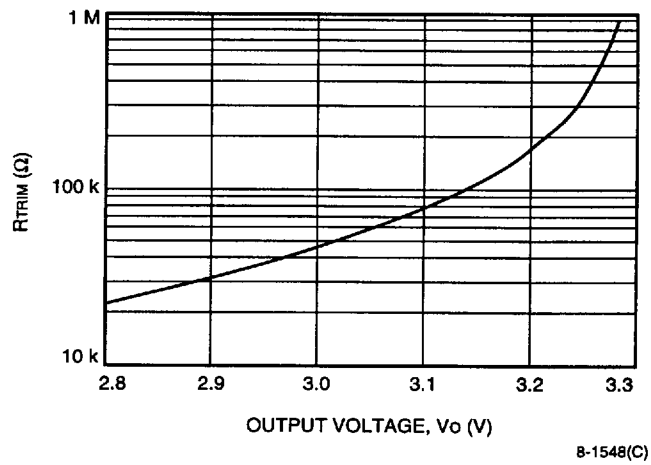


Figure 19. NH020F and NH020F2 $R_{trim\text{-}down}$ Test Results

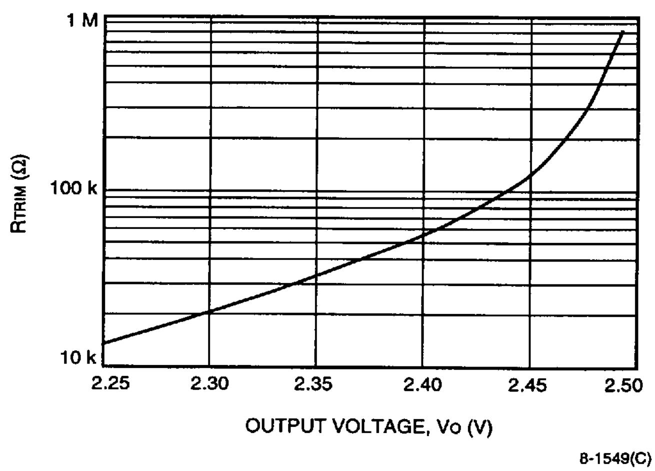


Figure 20. NH020G $R_{trim\text{-}down}$ Test Results

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:

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

Feature Descriptions (continued)

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

The test results for this configuration are displayed in Figure 21, Figure 22, and Figure 23.

Leave the TRIM pin open if not using that feature.

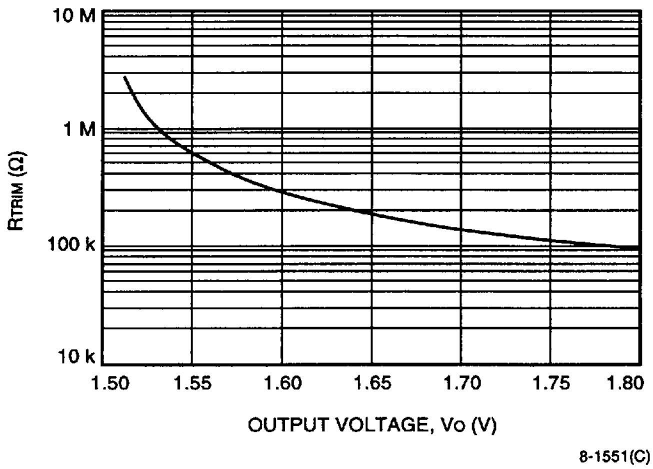


Figure 21. NH020M and NH020M2 Rtrim-up Test Results

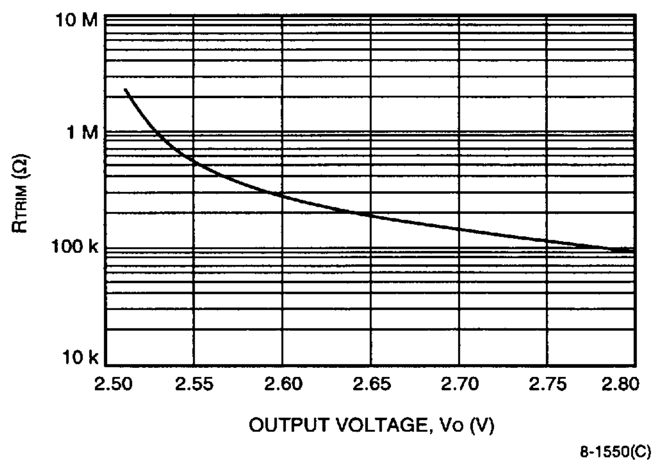


Figure 22. NH020G Rtrim-up Test Results

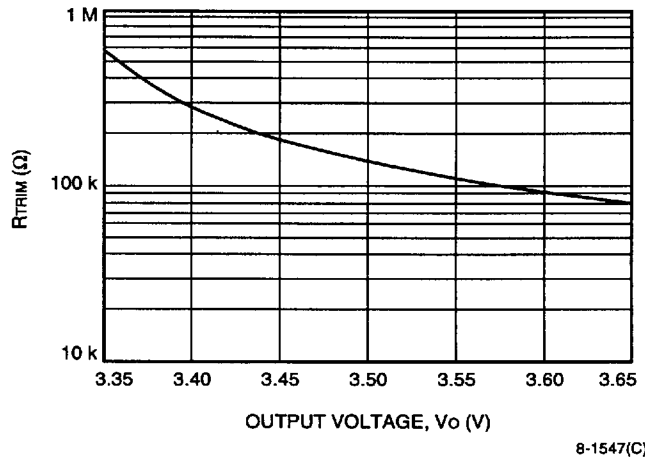
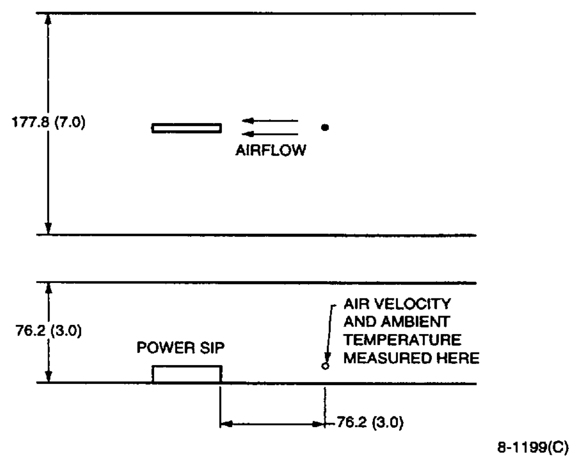


Figure 23. NH020F and NH020F2 Rtrim-up Test Results

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 24 was used to collect data for Figure 29. 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 24. Thermal Test Setup

Thermal Considerations (continued)

Proper cooling can be verified by measuring the power SIP's temperature at lead 7 of Q31 as shown in Figure 25.

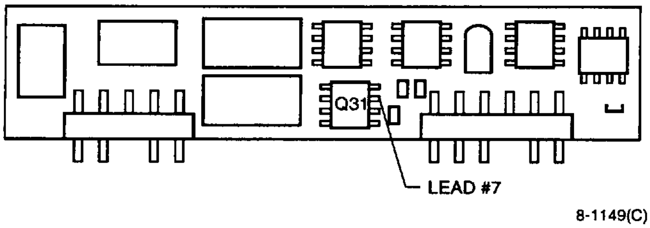


Figure 25. Temperature Measurement Location

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.

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 26, 27, and 28 show typical heat dissipation for the SIP over a range of output currents.

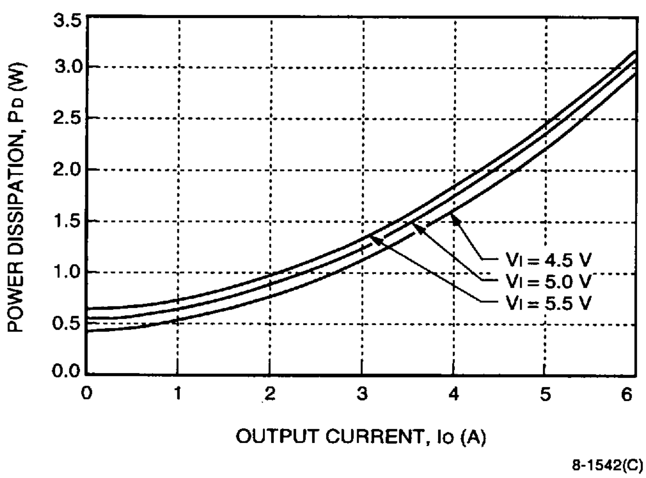


Figure 26. NH020M and NH020M2 Power Dissipation vs. Output Current

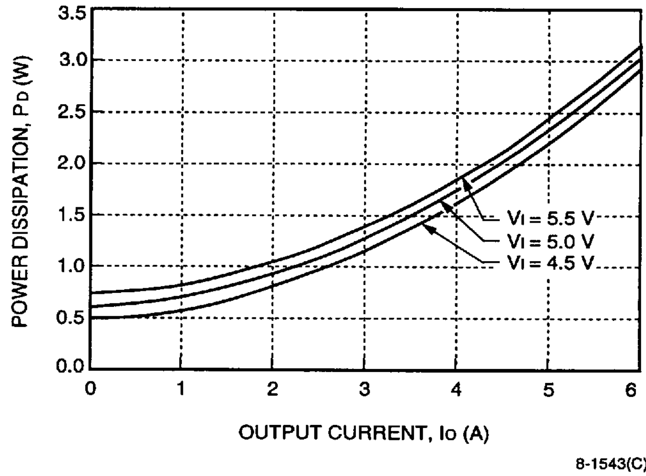


Figure 27. NH020G Power Dissipation vs. Output Current

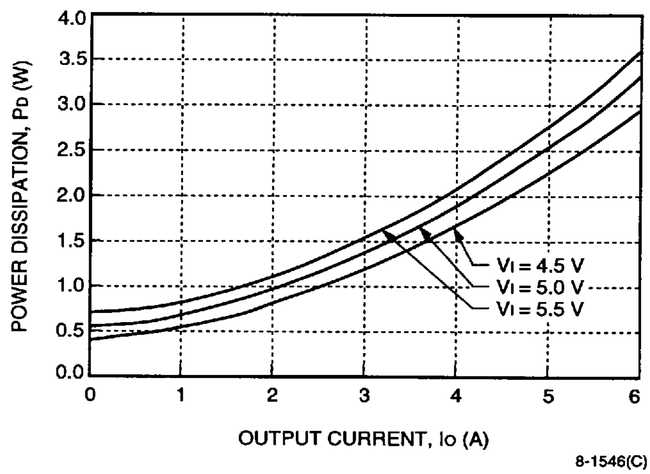


Figure 28. NH020F and NH020F2 Power Dissipation vs. Output Current

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 29.

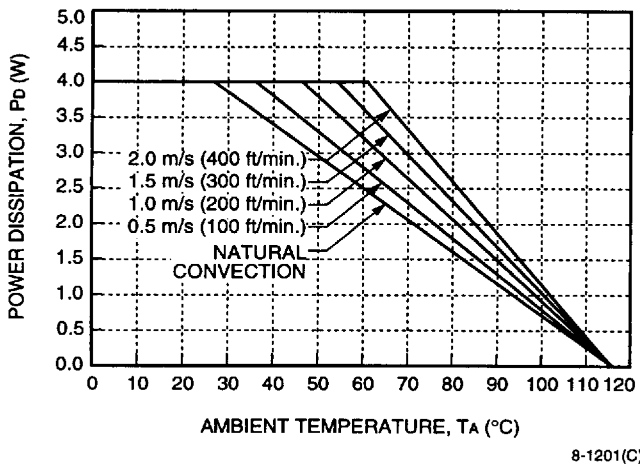


Figure 29. Power Derating vs. Local Ambient Temperature and Air Velocity

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 25 to ensure it does not exceed 115 °C.

Layout Considerations

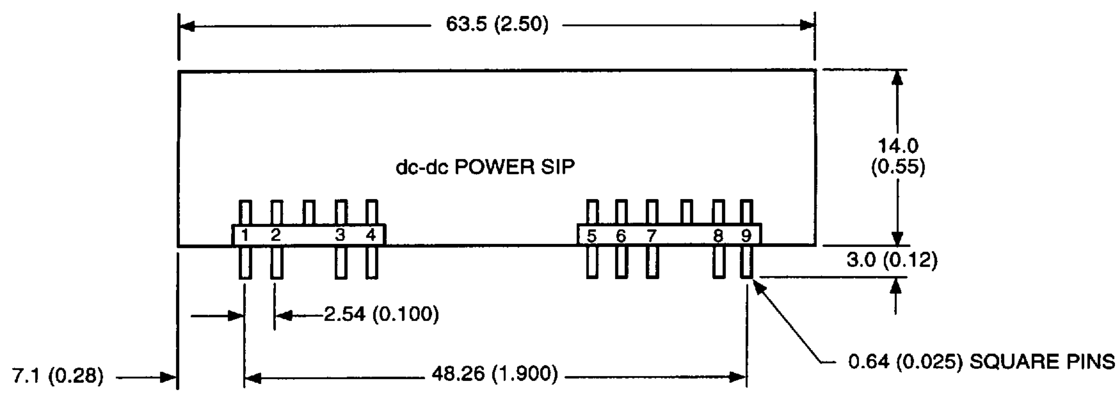
Copper paths must not be routed between pins 2 and 3 and pins 7 and 8.

Outline Diagram

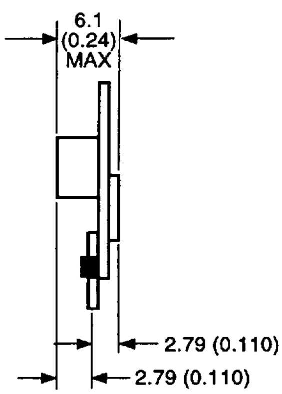
Dimensions are in millimeters and (inches).

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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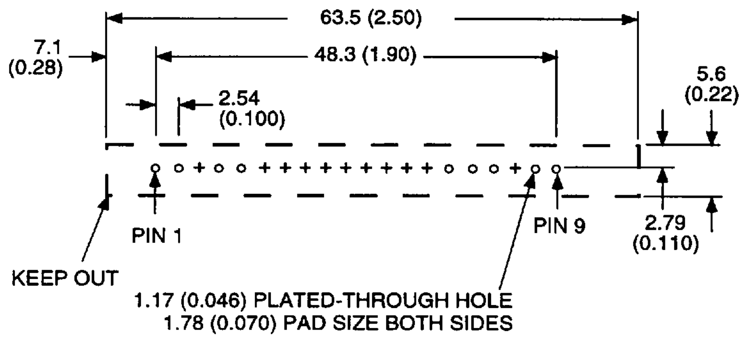
Recommended Hole Pattern

Component-side footprint.

Dimensions are in millimeters and (inches).



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

Ordering Information

For assistance in ordering options, please contact your Microelectronics Group Account Manager or Application Engineer for pricing and availability of options.

Input Voltage	Output Voltage	Output Power	Device Code	Options	Comcode
5 V	1.5 V	9.0 W	NH020M	—	107870065
5 V	1.5 V	9.0 W	NH020M2	Tight Tolerance Output	107988412
5 V	2.5 V	15 W	NH020G	—	107917114
5 V	3.3 V	20 W	NH020F	—	107221145
5 V	3.3 V	20 W	NH020F2	Tight Tolerance Output	107933426