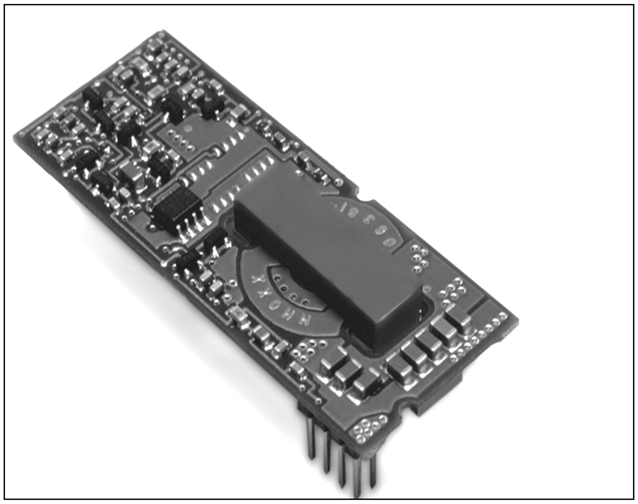
Advance Data Sheet
August 1997

tyco Electronics

NH050x-LP Series Power Modules: 5 Vdc Input; 1.5 Vdc to 3.3 Vdc Output; 15 A



The NH050x-LP Power Modules use advanced, surface-mount technology and deliver high-quality, compact, dc-dc conversion at an economical price.

Applications

- Distributed power architectures
- Servers
- Workstations
- Desktop computers

Features

- Non-isolated output
- Small size: 76.2 mm x 25.4 mm x 8.6 mm (3.00 in. x 1.00 in. x 0.34 in.)
- High efficiency: 91% typical
- Constant frequency
- Remote sense
- Remote on/off
- Output voltage adjustment: 90% to 110% of $V_{O,\ nom}$
- Overcurrent protection
- Thermal shutdown
- Synchronization capability
- Parallelable (current sharing)
- Interleaved control
- Designed to meet EN60950
- *UL** Recognition, *CSA*† Certification, and VDE Licensing pending
- Meets FCC and VDE Class A radiated limits

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

Description

The NH050x-LP Power Modules are non-isolated dc-dc converters that operate over an input voltage range of 4.5 Vdc to 5.5 Vdc and provide a regulated output of 3.3 Vdc, 2.5 Vdc, 2.0 Vdc, or 1.5 Vdc. The open frame power modules have a maximum output current rating of 15 A at typical full-load efficiencies of 91%. Modules can be connected in parallel for increased current capability. Synchronization pins are provided to lock operating frequencies. Interleaved control reduces input and output ripple currents during parallel operation.

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.

Ratings apply to all devices.

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*: NH050x-LP	T_A	0	45	°C
Storage Temperature	T_{stg}	–55	125	°C

* Forced convection—400 lfm minimum. Higher ambient temperatures 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:					
Start-up	V_I	4.75	—	—	Vdc
Continuous Operation	V_I	4.5	5.0	5.5	Vdc
Maximum Input Current (V_I = 0 V to 5.5 V; $I_O = I_{O,\ max}$): NH050x-LP	$I_{I,\ max}$	—	—	16	A
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 500 nH source impedance; see Figure 1.)	—	—	300	—	mAp-p
Input Ripple Rejection (120 Hz)	—	—	60	—	dB

Fusing Considerations

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

This power module 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, dc fuse with a maximum rating of 20 A (see Safety Considerations section). Based on the information provided in this data sheet on inrush energy and maximum dc input current, the same type of fuse with a lower rating can be used. Refer to the fuse manufacturer's data for further information.

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.) (See Figure 3.)	NH050M-LP NH050S1R8-LP NH050G-LP NH050F-LP	V_O V_O V_O V_O	1.43 1.71 2.40 3.16	— — — —	1.58 1.89 2.60 3.44	Vdc Vdc Vdc Vdc
Output Voltage Set Point (V_I = 5.0 V; $I_O = I_{O,\,max}$; T_A = 25 °C)	NH050M-LP NH050S1R8-LP NH050G-LP NH050F-LP	$V_{O,\,set}$ $V_{O,\,set}$ $V_{O,\,set}$ $V_{O,\,set}$	1.46 1.74 2.43 3.18	1.5 1.8 2.5 3.3	1.55 1.86 2.58 3.39	Vdc Vdc Vdc 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 50 °C)	All	—	—	—	17	mV
Output Ripple and Noise (See Figure 2.):						
RMS	All	—	—	—	25	mVrms
Peak-to-peak (5 Hz to 20 MHz)	All	—	—	—	100	mVp-p
Output Current*	All	I_O	0	—	15.0	A
Output Current-limit Inception (V_O = 90% of $V_{O,\,set}$; see Feature Descriptions section.)	All	I_O	103	—	200	%$I_{O,\,max}$
Efficiency (V_I = 5.0 V; $I_O = I_{O,\,max}$; T_A = 25 °C; see Figure 3.)	NH050M-LP NH050S1R8-LP NH050G-LP NH050F-LP	η η η η	TBD TBD TBD TBD	82 83 88 91.5	— — — —	% % % %
Dynamic Response ($\Delta I_O/\Delta t$ = 1 A/10 µs, V_I = 5.0 V, T_A = 25 °C):						
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	—	—	20	—	mV
Settling Time (V_O < 10% peak deviation)	All	—	—	200	—	µs

* Forced convection—400 lfm minimum.

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (I_O = 80% of $I_{O,\,max}$; T_A = 40 °C)		1,000,000		hr
Weight	—	—	14 (0.5)	g (oz.)

Cleanliness Requirements

The open frame (no case or potting) power modules meet specification J-STD-001B. These requirements state that solder balls must be attached and their size should not compromise minimum electrical spacing of the power module.

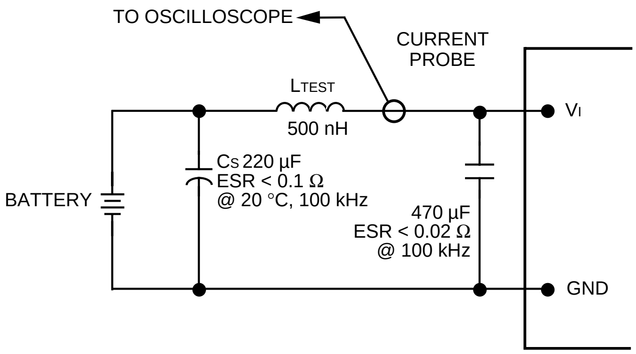
The cleanliness designator of the open frame power module is C00 (per J specification).

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.

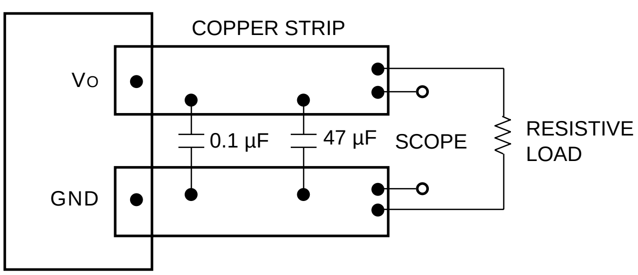
Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface					
(V_I = 4.5 V to 5.5 V; open collector pnp transistor or equivalent; signal referenced to GND terminal; see Figure 6 and Feature Descriptions section.):					
Logic Low (ON/OFF pin open)—Module On:					
$I_{on/off}$ = 0.0 µA	$V_{on/off}$	0	—	0.3	V
$V_{on/off}$ = 0.3 V	$I_{on/off}$	—	—	50	µA
Logic High ($V_{on/off}$ > 2.8 V)—Module Off:					
$I_{on/off}$ = 10 mA	$V_{on/off}$	—	—	6.0	V
$V_{on/off}$ = 5.5 V	$I_{on/off}$	—	—	10	mA
Turn-on Time					
(I_O = 80% of $I_{O,\ max}$; V_O within ±1% of steady state)	—	—	3.0	—	ms
Output Voltage Adjustment					
(See Feature Descriptions section.):					
Output Voltage Remote-sense Range:					
For $V_O \geq 2.5$ V	—	—	—	10	% $V_{O,\ nom}$
For $V_O < 2.5$ V	—	—	—	20	% $V_{O,\ nom}$
Output Voltage Set-point Adjustment Range (Trim):					
For $V_O \geq 2.5$ V	—	90	—	110	% $V_{O,\ nom}$
For $V_O < 2.5$ V	—	100	—	120	% $V_{O,\ nom}$
Over Temperature Shutdown (See Feature Descriptions section.)	T_C	—	120	—	°C
Current Share Accuracy—2 Units in Parallel	—	—	10	—	%$I_{O,\ rated}$
External Synchronization:					
Clock Amplitude	—	4.5	5.0	5.5	Vp-p
Duty Cycle	—	5	50	95	%
Rise and Fall Time of Clock Signal	—	—	50	75	ns
Capture Frequency Range	—	285	300	325	kHz
Fan-out	—	—	—	1	—

Test Configurations



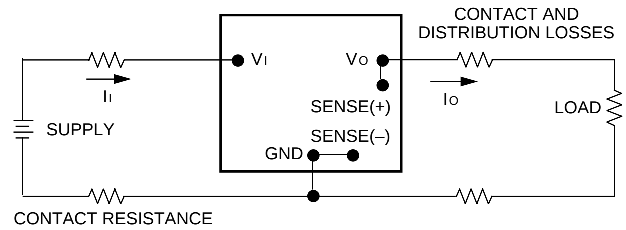
Note: Input reflected-ripple current is measured with a simulated source inductance of 500 nH. Capacitor C_S offsets possible battery impedance. Current is measured at the input of the module.

Figure 1. Input Reflected-Ripple Test Setup



Note: Use a 0.1 µF ceramic capacitor and a 47 µF aluminum or tantalum capacitor (ESR < 0.1 @ 100 kHz). Scope measurement should be made using a BNC socket. Position the load between 50 mm and 80 mm (2 in. and 3 in.) from the module.

Figure 2. Peak-to-Peak Output Noise Measurement Test Setup



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

$$\eta = \frac{V_O \times I_O}{V_I \times I_I} \times 100$$

Figure 3. Single-Output Voltage and Efficiency Measurement Test Setup

Design Considerations

Input Source Impedance

The power module should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the power module. 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 470 µF electrolytic capacitor with an ESR ≤ 0.02 Ω @ 100 kHz. Verify the quality and layout of these capacitors by ensuring that the ripple across the module input terminals is less than 1 Vp-p at full load. (See Figures 1, 4, and 5.)

The 470 µF electrolytic capacitor (C_1) should be added across the input of the power module 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. The input capacitor for the power module should be rated to handle 10 Arms.

When using a tantalum input capacitor, take care not to exceed the tantalum capacitor power rating because of the capacitor's failure mechanism (for example, a short circuit).

Design Considerations (continued)

Input Source Impedance (continued)

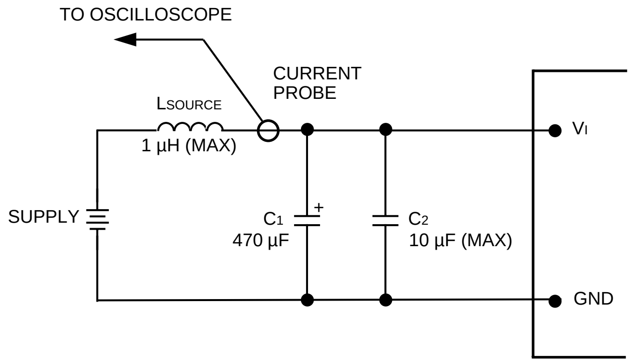


Figure 4. Setup with External Capacitor to Reduce Input Ripple Voltage

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 power module, provided the source inductance (L_{SOURCE}) is less than 1 µH (see Figure 4).

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 5). The filter inductor should be rated to handle the maximum power module input current of 16 Adc for the NH050F-LP.

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 module.

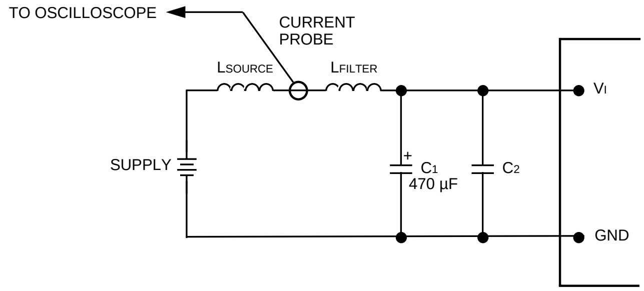


Figure 5. Setup with External Input Filter to Reduce Input Reflected-Ripple Current and Ensure Stability

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 20 A normal-blow fuse in the ungrounded lead.

Electrical 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.

Under some extreme overcurrent conditions, the unit may latch off. Once the fault is removed, the unit can be reset by toggling the remote on/off signal for one second or by cycling the input power.

Feature Descriptions

Remote On/Off

To turn the power module on and off, the user must supply a switch to control the voltage at the on/off terminal ($V_{on/off}$). The switch should be an open collector pnp transistor connected between the on/off terminal and the V_I terminal or its equivalent (see Figure 6).

During a logic low when the ON/OFF pin is open, the power module 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.

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

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.

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

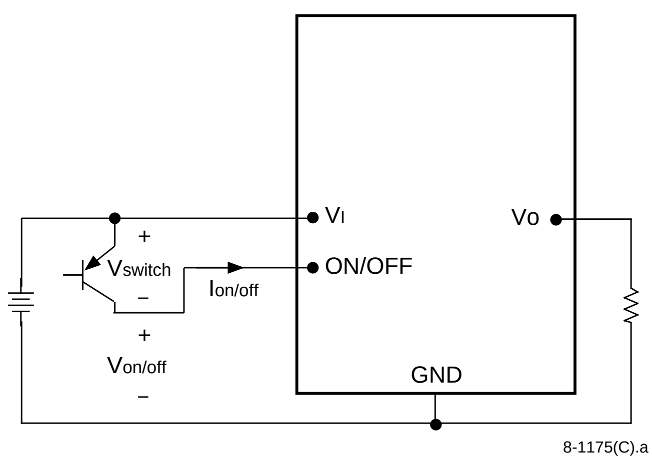


Figure 6. Remote On/Off Implementation

Remote Sense

Remote sense minimizes the effects of distribution losses by regulating the voltage at the remote-sense connections. The voltage between the remote-sense pins and the output terminals must not exceed the output voltage sense range given in the Feature Specifications table.

The voltage between the V_{OUT} and GND terminals must not exceed 110% of $V_{O,\ nom}$ for $V_O \geq 2.5$ V or 120% of $V_{O,\ nom}$ for $V_O < 2.5$ V. This limit includes any increase in voltage due to remote-sense compensation and output voltage set-point adjustment (trim). See Figure 7.

If not using the remote-sense feature to regulate the output at the point of load, then connect SENSE(+) to V_{OUT} and SENSE(–) to GND at the module.

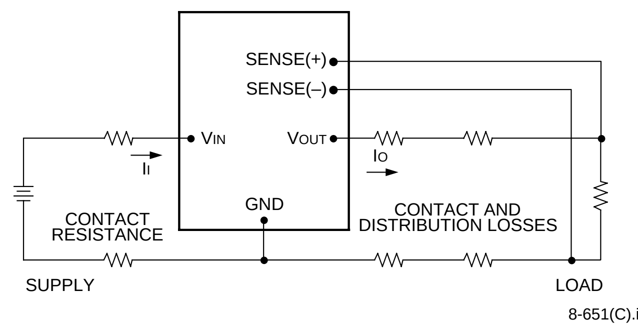


Figure 7. Effective Circuit Configuration for Single-Module Remote-Sense Operation

Feature Descriptions (continued)

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 modules that produce 2.5 V_{OUT} or greater 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 V_O pin decreases the output voltage set point as defined in the following equation.

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

$$R_{trim\text{-}down} = \left(\frac{18.23}{V_O - V_{O,\,adj}} - 47.2\right)k\Omega$$

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

$$R_{trim\text{-}down} = \left(\frac{6.98}{V_O - V_{O,\,adj}} - 24\right)k\Omega$$

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

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.

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

$$R_{trim\text{-}up} = \left(\frac{28}{V_{O,\,adj} - V_O} - 10\right)k\Omega$$

For all other modules:

$$R_{trim\text{-}up} = \left(\frac{28}{V_{O,\,adj} - V_O} - 33.2\right)k\Omega$$

If not using the trim feature, leave the TRIM pin open.

Overtemperature Shutdown

To provide additional protection in a fault condition, the unit is equipped with a nonlatched thermal shutdown circuit. The shutdown circuit engages when Q32 exceeds approximately 120 °C. The unit attempts to restart when Q32 cools down. The unit cycles on and off if the fault condition continues to exist. Recovery from shutdown is accomplished when the cause of the overheating condition is removed.

Parallel Operation

For additional power requirements, the power modules can be configured for parallel operation with forced load sharing (see Figure 8).

Good layout techniques should be observed for noise immunity. To implement forced load sharing, the following connections must be made:

- The PARALLEL pins of all units must be connected together. The paths of these connections should be as direct as possible.
- Connect the SYNC OUT pin of one module to the SYNC IN pin of another module according to the Module Synchronization section on the next page.
- All remote-sense pins must be connected to the power bus at the same point, i.e., connect all SENSE(+) pins to the (+) side of the power bus at the same point and all SENSE(–) pins to the (–) side of the power bus at the same point. Close proximity and directness are necessary for good noise immunity.

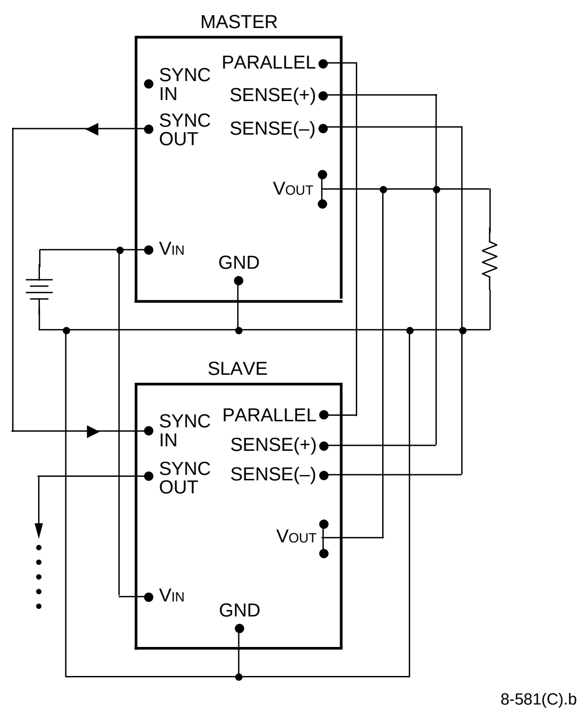


Figure 8. Wiring Configuration for Parallel Operation

Feature Descriptions (continued)

Module Synchronization

Any module can be synchronized to any other module or to an external clock using the SYNC IN or SYNC OUT pins.

SYNC IN Pin

The SYNC IN signal is referenced to $V_I(–)$. This pin can be connected either to an external clock or directly to the SYNC OUT pin of another NH050x-LP module.

If an external clock signal is applied to the SYNC IN pin, the signal must have the characteristics as shown in the Feature Specifications table. Operation outside the specified frequency band will detrimentally affect the performance of the module and must be avoided.

If the SYNC IN pin is connected to the SYNC OUT pin of another module, the connection should be as direct as possible, and the $V_I(–)$ pins of the modules must be shorted together.

If no connection is made to the SYNC IN pin, the module will operate from its own internal clock.

SYNC OUT Pin

This pin contains a clock signal referenced to the $V_I(–)$ pin. The frequency of this signal will equal either the module's internal clock frequency or the frequency established by an external clock applied to the SYNC IN pin.

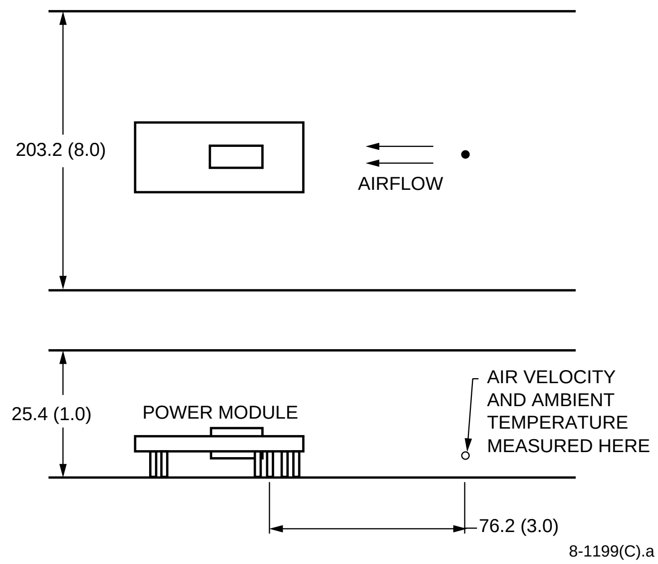
When synchronizing several modules together, the modules should be connected in a daisy-chain fashion where the SYNC OUT pin of one module is connected to the SYNC IN pin of another module. Each module in the chain will synchronize to the frequency of the first module in the chain.

To avoid loading effects, ensure that the SYNC OUT pin of any one module is connected to the SYNC IN pin of only one module. Any number of modules can be synchronized in this daisy-chain fashion.

Thermal Considerations

The power modules operate 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 9 was used to collect data for Figure 12. Note that the airflow is parallel to the long axis of the module. The derating data applies to airflow along either direction of the module's long axis.



Note: Dimensions are in millimeters and (inches).

Figure 9. Thermal Test Setup

Thermal Considerations (continued)

Proper cooling can be verified by measuring the power module's temperature at lead 7 of Q32 as shown in Figure 10. The temperature at this location should not exceed 115 °C.

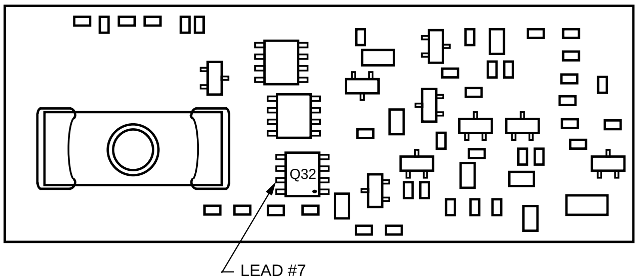


Figure 10. Temperature Measurement Location

Convection Requirements for Cooling

To predict the approximate cooling needed for the module, determine the power dissipated by the unit for the particular application. Figure 11 shows typical heat dissipation for the module over a range of output currents.

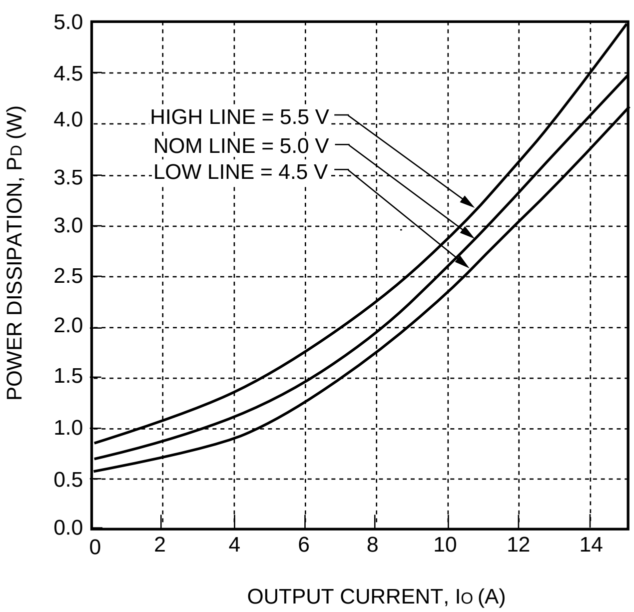


Figure 11. NH050F Power Dissipation vs. Output Current, T_A = 25 °C

With the known heat dissipation and a given local ambient temperature, the minimum airflow can be chosen from the derating curves in Figure 12.

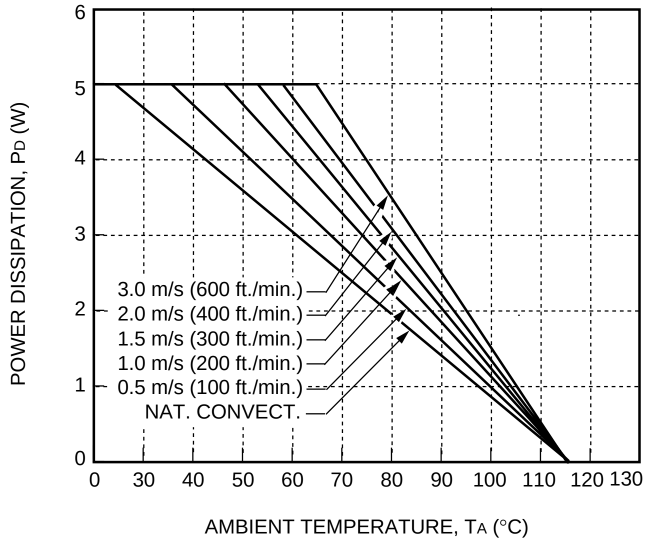


Figure 12. NH050x Power Derating vs. Local Ambient Temperature and Air Velocity

For example, if the NH050F-LP dissipates 3.5 W of heat, the minimum airflow in a 60 °C environment is 0.5 m/s (100 ft./min.).

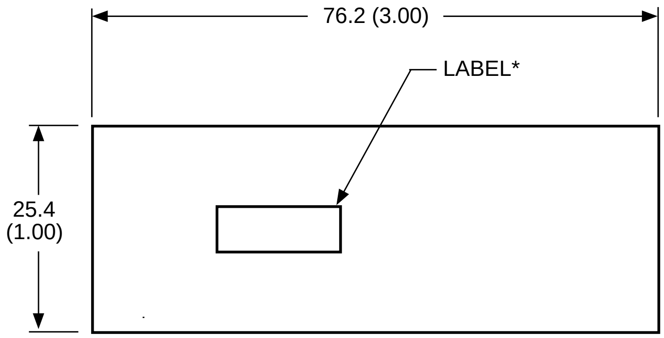
Keep in mind that these derating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be checked as shown in Figure 10 to ensure it does not exceed 115 °C.

Outline Diagram

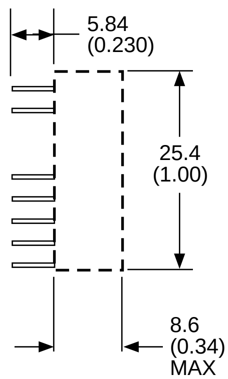
Dimensions are in millimeters and (inches).

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

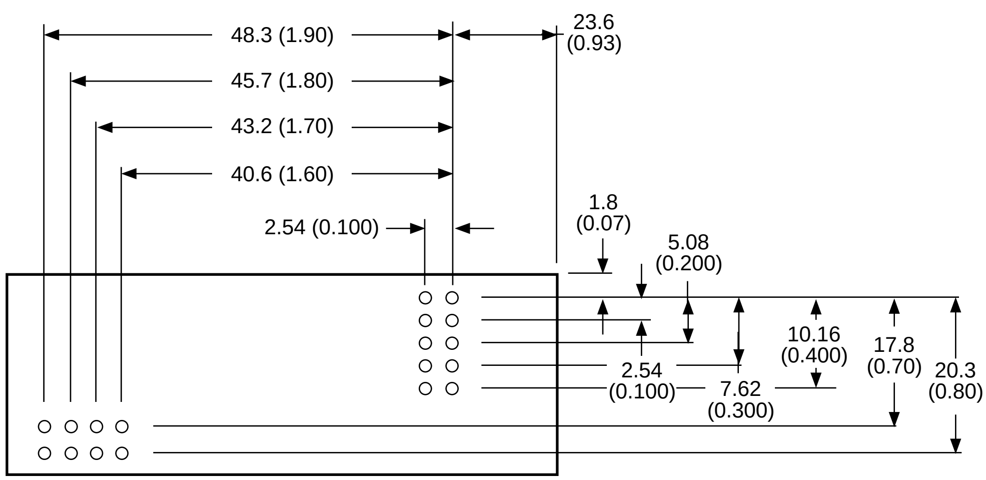
Top View



Side View



Bottom View



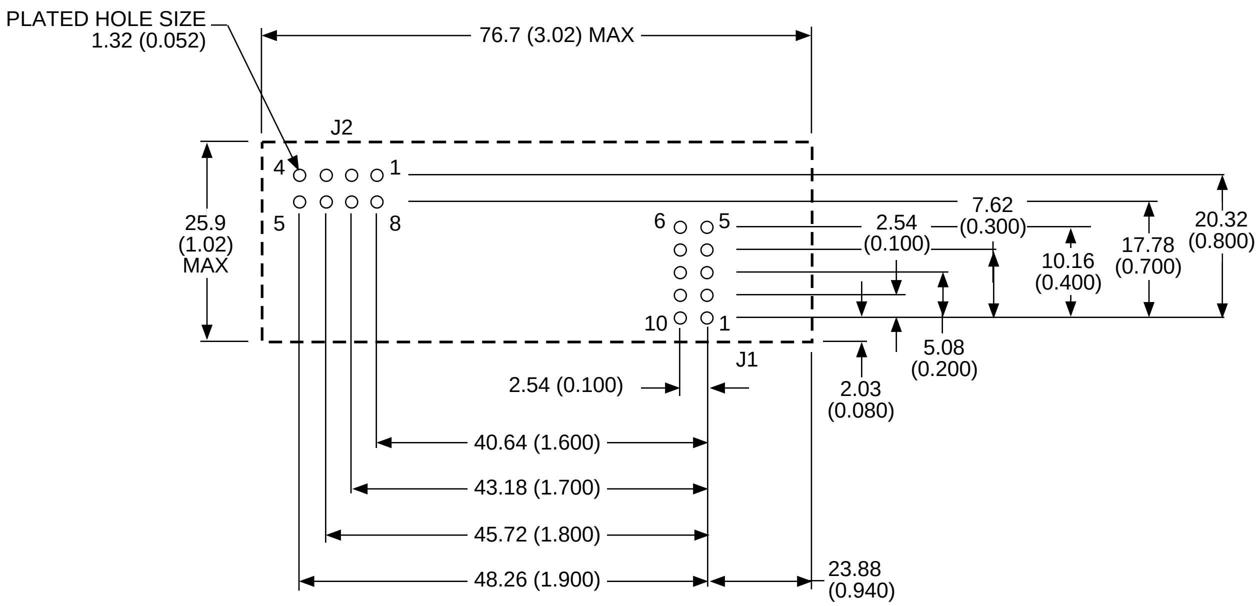
8-1176(C).c

* Label includes product designation and date code.

Recommended Hole Pattern

Dimensions are in millimeters and (inches).

Tolerances: x.xx mm ± 0.13 mm (x.xxx in. ± 0.005 in.).



8-1176(C).c

Pin	Function
J1 - 1	Remote ON/OFF
J1 - 2	PARALLEL
J1 - 3	TRIM
J1 - 4	GND
J1 - 5	SYNC IN
J1 - 6	SYNC OUT
J1 - 7	GND
J1 - 8	VIN
J1 - 9	VIN
J1 - 10	VIN

Pin	Function
J2 - 1	SENSE(–)
J2 - 2	SENSE(+)
J2 - 3	VOUT
J2 - 4	VOUT
J2 - 5	VOUT
J2 - 6	VOUT
J2 - 7	GND
J2 - 8	GND

Ordering Information

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

Input Voltage	Output Voltage	Output Power	Device Code	Comcode
5 V	1.5 V	22.5 W	NH050M-LP	TBD
5 V	1.8 V	27 W	NH050S1R8-LP	TBD
5 V	2.5 V	37.5 W	NH050G-LP	TBD
5 V	3.3 V	50 W	NH050F-LP	108013715

Notes

Notes

Notes

Tyco Electronics Power Systems, Inc.
3000 Skyline Drive, Mesquite, TX 75149, USA
+1-800-526-7819 FAX: +1-888-315-5182
(Outside U.S.A.: **+1-972-284-2626**, FAX: +1-972-284-2900
http://power.tycoelectronics.com

August 1997
DS97-208EPS