

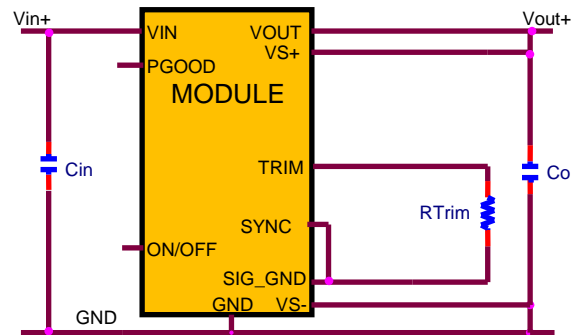
# IND072 Hornet™: Non-Isolated DC-DC Voltage Regulator Modules

12Vdc input; 0.6Vdc to 3.3Vdc output; 66W Max Power



## Applications

- ✓ Industrial Equipment
- ✓ Control Boards
- ✓ Test Equipment



## Electrical Features

- 12V Input voltage with  $\pm 20\%$  Tolerance
- Output voltage programmable from 0.6Vdc to 3.3Vdc via external resistor
- Remote On/Off for optional external control
- Power Good signal for external monitoring
- Fixed switching frequency
- Output overcurrent protection (non-latching)

## Mechanical Features

- Small size: 12.2 mm x 12.2 mm x 8.5 mm (0.48 in x 0.48 in x 0.335 in)
- Operating range:  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$  ambient
- Operating shock to 40G per Mil Std. 810G, Method 516.4 Procedure I
- Operating vibration per Mil Std. 810G, Method 514.5 Procedure I

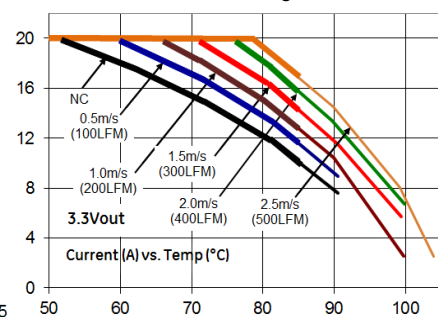
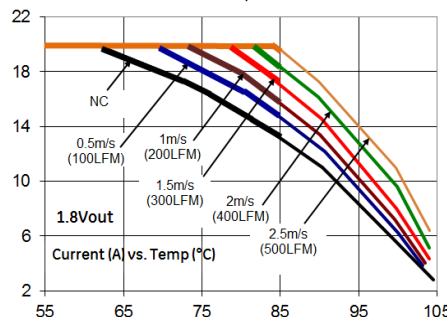
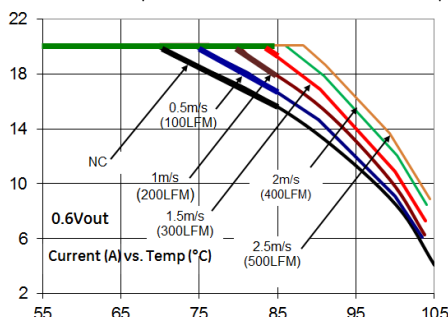
## Process and Safety

- Qualified for 1000h High Temperature Operating Bias, 1000h 85RH/85°C Temperature, Humidity and Bias, 700 cycle  $-40$  to  $125^{\circ}\text{C}$  thermal cycling
- ANSI/UL# 60950-1 2<sup>nd</sup> Revised October 14, 2014, CSA† C22.2 No. 60950-1-07, Second Ed. + A2:2014 (MOD) Recognized, DIN EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011, + A2:2013 (VDE† 0805-1) Licensed
- ISO\*\* 9001 and ISO 14001 certified manufacturing facilities
- Compliant to RoHS II EU "Directive 2011/65/EU"
- Compatible in a Pb-free or SnPb reflow environment.
- Suitable for aqueous clean.
- Suitable for conformal coating with dip and vapor deposition. Conformal coating can provide the protection to meet Salt Fog Test per IEC 60068-2-52 (Severity 3) and Mixed Gas Flow test per Telcordia GR-3108 Outdoor Levels.
- 3 year warranty

| Device Code | Input Voltage | Output Voltage | Output Current (Max.) | On/Off Logic | Comcode     |
|-------------|---------------|----------------|-----------------------|--------------|-------------|
| IND072      | 9.6 – 14.4Vdc | 0.6 – 3.3Vdc   | 20A                   | Negative     | 1600102900A |

## Thermal Performance

Full rated output with natural convection up to  $70^{\circ}\text{C}$  at 0.6Vout and up to  $52^{\circ}\text{C}$  at 3.3Vout.. Thermal curves for 3 voltages below.



## Electrical Specifications

| Parameter  | Device                              | Symbol                   | Min                                | Typ    | Max  | Unit                  |
|--|-------------------------------------|--------------------------|------------------------------------|--------|------|-----------------------|
| Operating Input Voltage  | All                                 | $V_{IN}$                 | 9.6                                | 12     | 14.4 | Vdc                   |
| Input No Load Current<br>( $V_{IN} = 12.0\text{Vdc}$ , $I_o = 0$ , module enabled)                                 | $V_{O, \text{set}} = 0.6\text{Vdc}$ | $I_{IN, \text{No load}}$ |                                    | 47     |      | mA                    |
|  | $V_{O, \text{set}} = 3.3\text{Vdc}$ | $I_{IN, \text{No load}}$ |                                    | 120    |      | mA                    |
| External Capacitance, Ceramic ESR $\geq 1\text{m}\Omega$   | All                                 | $C_{O, \text{max}}$      | 2x47                               | —      | 200* | $\mu\text{F}$         |
| Efficiency 12V <sub>INDC</sub> , $T_A = 25^\circ\text{C}$ , $I = 12\text{A}$ , $V_o = 0.6\text{ to }3.3\text{Vdc}$ |                                     | $\eta$                   | 78.9(0.6V), 90.8(1.8V), 93.9(3.3V) |        |      | %                     |
| Switching Frequency  | All                                 | $f_{\text{SW}}$          | —                                  | 500    | —    | kHz                   |
| Output Voltage (Over all line, load, and temperature conditions)   | All                                 | $V_O, \text{set}$        | -3.0                               | —      | +3.0 | % $V_{O, \text{set}}$ |
| On/Off Logic High Input High Voltage   | All                                 | $V_{IH}$                 | 2.1                                | —      | 7    | Vdc                   |
| On/ Off Logic Low Input Low Voltage  | All                                 | $V_{IL}$                 | -0.2                               | —      | 0.8  | Vdc                   |
| <b>PGOOD (Power Good)</b>  |                                     |                          |                                    |        |      |                       |
| <b>Signal Interface Open Drain, <math>V_{\text{supply}} \leq 5\text{VDC}</math></b>                                |                                     |                          |                                    |        |      |                       |
| Overvoltage threshold for PGOOD ON   | All                                 |                          |                                    | 108.33 |      | % $V_{O, \text{set}}$ |
| Overvoltage threshold for PGOOD OFF  | All                                 |                          |                                    | 112.5  |      | % $V_{O, \text{set}}$ |
| Undervoltage threshold for PGOOD ON  | All                                 |                          |                                    | 91.67  |      | % $V_{O, \text{set}}$ |
| Undervoltage threshold for PGOOD OFF   | All                                 |                          |                                    | 87.5   |      | % $V_{O, \text{set}}$ |
| Pulldown resistance of PGOOD pin   | All                                 |                          |                                    | 40     | 70   | $\Omega$              |
| Sink current capability into PGOOD pin   | All                                 |                          |                                    |        | 5    | mA                    |
| <b>Frequency Synchronization (SYNC Pin)</b>  |                                     |                          |                                    |        |      |                       |
| Synchronization Frequency Range ( $2 \times f_{\text{switch}}$ )   | All                                 |                          | 950                                | 1000   | 1050 | kHz                   |
| High-Level Input Voltage   | All                                 | $V_{IH}$                 | 2                                  |        |      | V                     |
| Low-Level Input Voltage  | All                                 | $V_{IL}$                 |                                    |        | 0.4  | V                     |
| Minimum Pulse Width, SYNC  | All                                 | $t_{\text{SYNC}}$        | 100                                |        |      | ns                    |
| Maximum SYNC rise time   | All                                 | $t_{\text{SYNC\_SH}}$    | 100                                |        |      | ns                    |

\*Additional External Capacitance possible using Tunable Loop

## Characteristic Curves

The following figures provide typical characteristics for the IND072 Hornet<sup>™</sup> at 25°C.

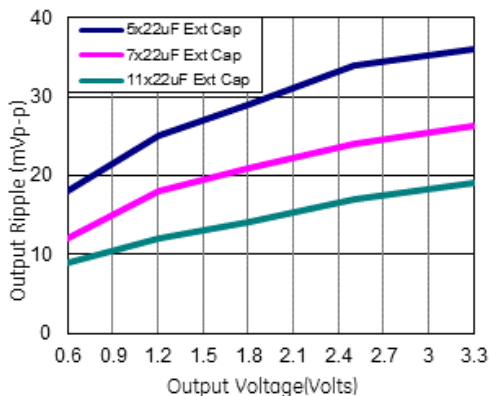


Figure 1. Output Ripple Voltage for various output voltages and external caps @12Vin. Additional Decoupling cap of 0.1uF used on input and output side

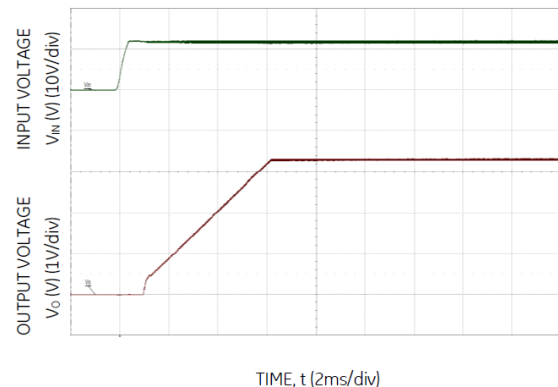


Figure 2. Typical Start-up using Input Voltage ( $V_{IN} = 12\text{V}$ ,  $V_{out} = V_{out, \text{max}}$ ,  $I_{out} = I_{out, \text{max}}$ )

## Trim

Without an external resistor between Trim and GND pins, the output of the module will be 0.6Vdc.  $R_{trim}$  for a desired output voltage, is as per the following table. The formula in the last column helps determine  $R_{trim}$  for other voltages within range.

|                          |      |     |     |     |      |     |       |     |  |
|--------------------------|------|-----|-----|-----|------|-----|-------|-----|--|
| $V_o$ (V)                | 0.6  | 0.9 | 1.0 | 1.2 | 1.5  | 1.8 | 2.5   | 3.3 | $R_{trim} = \left[ \frac{12}{(V_o - 0.6)} \right] k\Omega$ |
| $R_{trim}$ (k $\Omega$ ) | Open | 40  | 30  | 20  | 13.3 | 10  | 6.316 | 4.4 |  |

## Safety Considerations

For safety agency approval the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standards listed on the first page of this document. For the converter output to be considered meeting the requirements of safety extra-low voltage (SELV), the input must meet SELV requirements. The power module has extra-low voltage (ELV) outputs when all inputs are ELV. The units were tested using an external Littelfuse 456 series fast-acting fuse rated at 30A in the ungrounded input.

## Tunable Loop

The module is designed for 200uF capacitor on its output. For applications where more than 200uF capacitors would be used on the output, an additional Resistor ( $R_{tune}$ ) and Capacitor ( $C_{tune}$ ) would be required in the circuit schematic to compensate for the additional capacitance. The placement is between the Sense+ pin and Trim pin as per figure below:

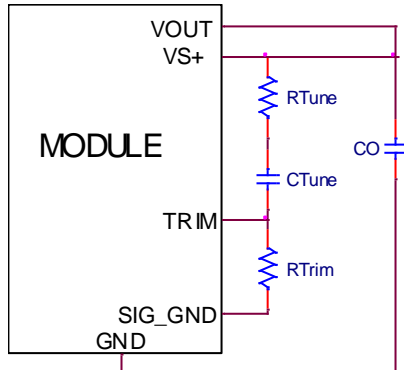


Figure 3. Circuit diagram showing connection of  $R_{TUNE}$  and  $C_{TUNE}$  to tune the control loop of the module.

The recommended values for  $R_{tune}$  and  $C_{tune}$  for different amounts of external capacitance are as per the table below:

| Co         | 6x47 $\mu$ F | 8x47 $\mu$ F | 10x47 $\mu$ F | 20x47 $\mu$ F |
|------------|--------------|--------------|---------------|---------------|
| $R_{TUNE}$ | 300          | 300          | 300           | 300           |
| $C_{TUNE}$ | 820pF        | 1nF          | 1.5nF         | 2.7nF         |

## PowerGood (PGOOD)

This is an open-drain output to indicate that the output voltage is within the regulation limits of the module. The PGOOD signal will be de-asserted to a low state if any condition such as overtemperature, overcurrent or loss of regulation occurs that would result in the output voltage going  $\pm 10\%$  outside the setpoint value. If not used, leave unconnected.

## Synchronization (SYNC)

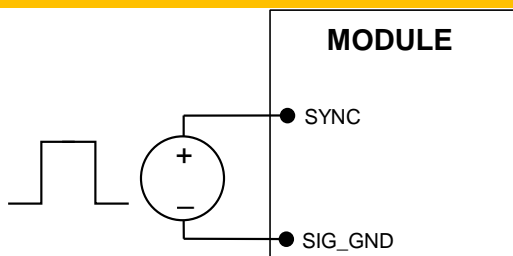


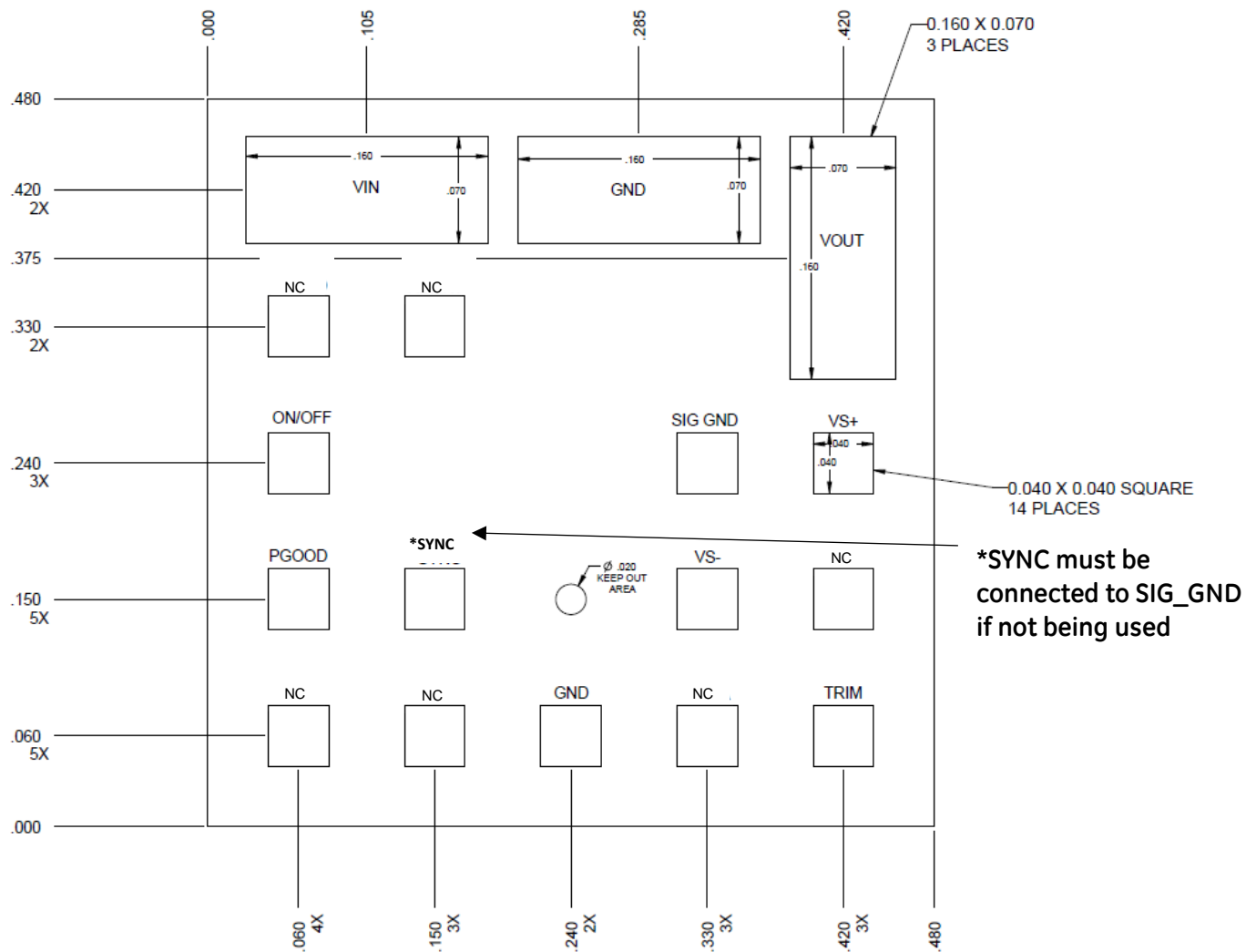
Figure 4. External source connections to synchronize switching frequency of the module

The module switching frequency can be synchronized to a signal with an external frequency within a specified range. Synchronization can be done by using the external signal applied to the SYNC pin of the module as shown in Fig. 39, with the converter being synchronized by the rising edge of the external signal. The Module switches at half the SYNC frequency. The Electrical Specifications table specifies the requirements of the external SYNC signal. If the SYNC pin is not used, the module should free run at the default switching frequency. **If synchronization is not being used, connect the SYNC pin to Sig\_GND.**

## Recommended Pad Layout

Dimensions are in millimeters and (inches).

Tolerances:  $x.x \text{ mm} \pm 0.5 \text{ mm}$  ( $x.xx \text{ in.} \pm 0.02 \text{ in.}$ ) [unless otherwise indicated]  $x.xx \text{ mm} \pm 0.25 \text{ mm}$  ( $x.xxx \text{ in.} \pm 0.010 \text{ in.}$ )



## Nozzle Recommendations

The minimum recommended inside nozzle diameter for reliable operation is 3mm. The maximum nozzle outer diameter, which will safely fit within the allowable component spacing, is 7 mm.

## Bottom Side / First Side Assembly

This module is not recommended for assembly on the bottom side of a customer board. If such an assembly is attempted, components may fall off the module during the second reflow process

## Lead Free Soldering

The modules are lead-free (Pb-free) and RoHS compliant and fully compatible in a Pb-free soldering process. Failure to observe the instructions below may result in the failure of or cause damage to the modules and can adversely affect long-term reliability

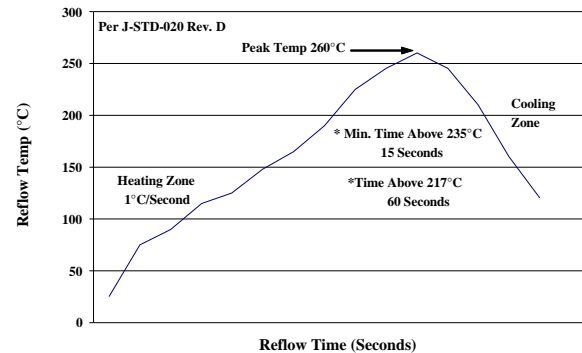
## MSL Rating

The modules have a MSL rating of 2a.

## Pb-free Reflow Profile

Power Systems will comply with J-STD-020 Rev. D (Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices) for both Pb-free solder profiles and MSL classification procedures. The suggested Pb-free solder paste is Sn/Ag/Cu (SAC).

The following profile is the recommended linear reflow profile using Sn/Ag/Cu solder. Soldering outside of the recommended profile requires testing to verify results and performance.



## Storage and Handling

J-STD-033 Rev. A (Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices) is recommended. Moisture barrier bags (MBB) with desiccant are required for MSL ratings of 2 or greater. These sealed packages should not be broken until time of use. Once the original package is broken, the floor life of the product at conditions of  $\leq 30^{\circ}\text{C}$  and 60% relative humidity varies according to the MSL rating (see J-STD-033A). The shelf life for dry packed SMT packages will be a minimum of 12 months from the bag seal date, when stored at the following conditions:  $< 40^{\circ}\text{C}$ ,  $< 90\%$  relative humidity.

## Post Solder Cleaning and Drying Considerations

Post solder cleaning is usually the final circuit-board assembly process prior to electrical board testing. The result of inadequate cleaning and drying can affect both the reliability of a power module and the testability of the finished circuit-board assembly

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