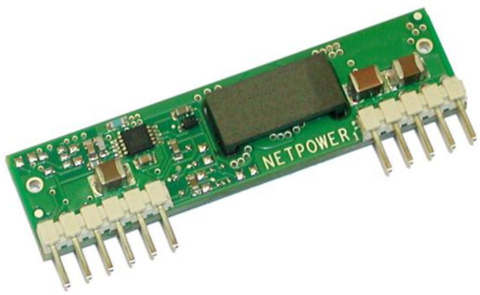
18-36V Input 9A Output Point-of-Load Converter



DOSA Compatible
RoHS Compliant Parts Available

Features

- High efficiency, 94% (24Vin, 12Vout@5A)
- Excellent thermal performance
- High output current: 9A
- Wide input voltage range: 18 - 36V
- Wide output voltage range: 5 - 15.5V
- Monotonic start-up into pre-biased load
- Output trim, Remote sense
- Switching frequency synchronization
- Small footprint: 2”×0.25’’×0.5’’
- All components meet UL† 94V0

Options

- Baseplate
- Negative/Positive enable logic
- Output over-voltage protection
- Output voltage tracking/Sequence

Part Numbering System

NAT	3	□□□	□	09	R	□	□
Series Name:	**Nominal Input Voltage:**	**Nominal Output Voltage:**	**Enabling Logic:**	**Rated Output Current:**	**Pin Length Options :**	**Electrical Options:**	**Mechanical Options** **Lead-free, (ROHS-6 Compliant)**
NAT	**3:** 18 -36V	**Unit:** 0.1V 050 = 5V 000=Variable	**P:** positive **N:** negative	Unit: A **09:** 9A	**R:** 0.2’’	**0:** Default **1:** Output tracking **2**: Output OVP **3**: Tracking and OVP **4**: Frequency Synch. **5**: OVP and synch.	**5:** None **6:** Baseplate

†UL is a registered trademark of Underwriters Laboratory Inc.

Absolute Maximum Ratings

Excessive stresses over these absolute maximum ratings can cause permanent damage to the converter. Also, exposure to absolute maximum ratings for extended periods of time can adversely affect the reliability of the converter. Operation should be limited to the conditions outlined under the Electrical Specification Section.

Parameter	Symbol	Min	Max	Unit
Input Voltage (continuous)	Vi	-0.5	38.5	Vdc
Operating Ambient Temperature (See Thermal Consideration section)	To	-40	85*	˚C
Storage Temperature	Tstg	-55	125	˚C

* For operation above 85ºC ambient temperature, please consult NetPower for derating guidance.

Electrical Specifications

These specifications are valid over the converter's full range of input voltage, resistive load, and temperature unless noted otherwise.

Input Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Input Voltage	Vi	18	24	36	Vdc
Input Current	Ii,max	-	-	9	A
Quiescent Input Current (Vin = 24, Vo = 3.3V)	Ii,Qsnt	-	50	70	mA
Standby Input Current	Ii,stdby	-	2		mA
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 1 µH source impedance)	-	-	20	-	mAp-p
Input Ripple Rejection (120 Hz)	-		30	-	dB
Input Turn-on Voltage Threshold	-		17		V

Output Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point Tolerance (Vi = 24 V; Io = Iomax; Ta = 25°C)	-	-2.0	-	2.0	%
Output Voltage Set Point Tolerance (over all conditions)	-	-2.5	-	3.50	%
Output Regulaton:					
Line Regulation (Vi = 9V to 36V, Io = 1/2 of load)	-	-	0.2		%Vo
Load Regulation (Io = Io,min to Io,max, Vi = 24V)	-	-	0.3		%Vo
Temperature (Ta = -40°C to 85 °C)	-	-	0.2		%Vo
Output Ripple and Noise Voltage (5 Hz to 20 MHz bandwidth, Vin = 24V)	Peak-to-peak -	-	2		%Vo
	RMS			1	%Vo
External Load Capacitance	-	-	-	2,000	µF
Output Current	Io	0	-	9	A
Output Power	Po	0		60	W
Output Current-limit Trip Point	Io,cli	-	170	-	%Iomax
Output Short-circuit Current, hiccup mode			2		A
Switching frequency	-	405	450	495	kHz
Output Over Voltage trip point (optional, hiccup mode)		115	125	135	%Vo
Voltage Tracking/Sequencing Slew Rate – Power UP				2	V/ms
Voltage Tracking/Sequencing Slew Rate – Power down				1	V/ms

Output Specifications (continued)

Parameter		Symbol	Min	Typ	Max	Unit
Efficiency (Vi = 24V; TA = 25ºC)	Vo = 5V, Io = 9A	η		88		%
	Vo = 12V, Io = 5A			94		%
Dynamic Response (Vi = 24V; Ta = 25°C; Load transient 0.1A/µs) Load step from 75% to 100% of full load: Peak deviation Settling time (to 10% band of Vo deviation) Load step from 100% to 75% of full load Peak deviation Settling time (to 10% band of Vo deviation)						 mV µs mV µs

General Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Remote Enable Negative Logic: Logic Low – Module On Logic High – Module Off	-	-	-	-	-
Positive Logic: Logic High – Module On Logic Low – Module Off	-	-	-	-	-
Logic Low: ION/OFF = 1.0mA VON/OFF = 0.0V Logic High: ION/OFF = 0.0µA Leakage Current	VON/OFF ION/OFF VON/OFF ION/OFF	0 - - - -	- - - -	1.2 1.0 15 50	V mA V µA
Over-temperature Protection	To	-	120	-	°C
Turn-on Time (Io = full load, Vo within 1% of setpoint)	-	-	6	-	ms
Calculated MTBF (Bellcore TR-332, 40°C, full load)			> 5		10^6-hour

Characteristic Curves

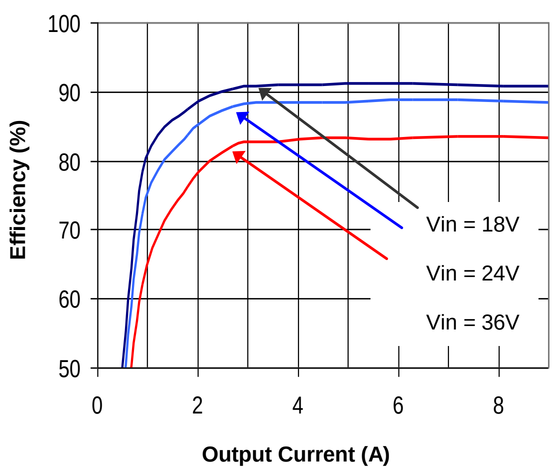


Figure 1(g). Efficiency vs. Load Current
(25°C, 5V output)

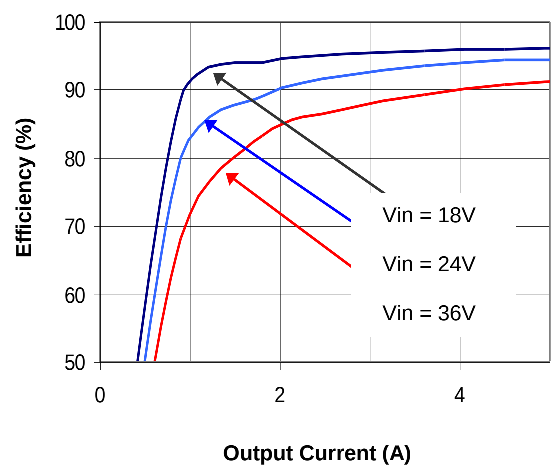


Figure 1(h). Efficiency vs. Load Current
(25°C, 12V output)

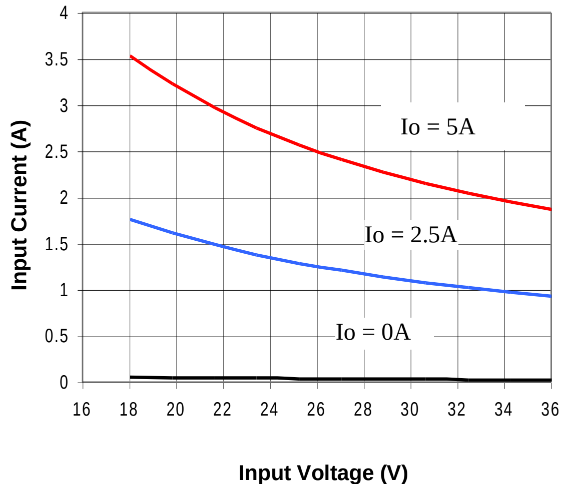


Figure 2. Input Characteristic (12V output)

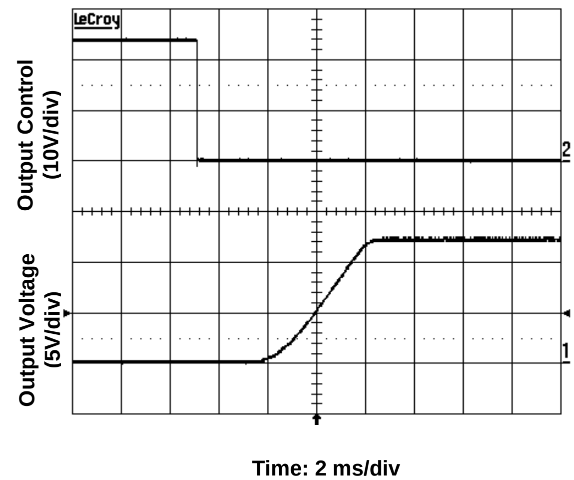


Figure 3. Start-Up from Enable Control
Input voltage 24V, Output current 5A, output voltage 12V.

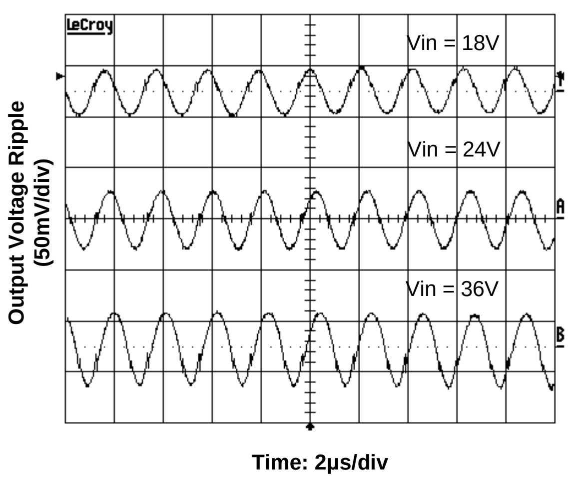


Figure 4. Output Ripple Voltage at 5V, 9A Output

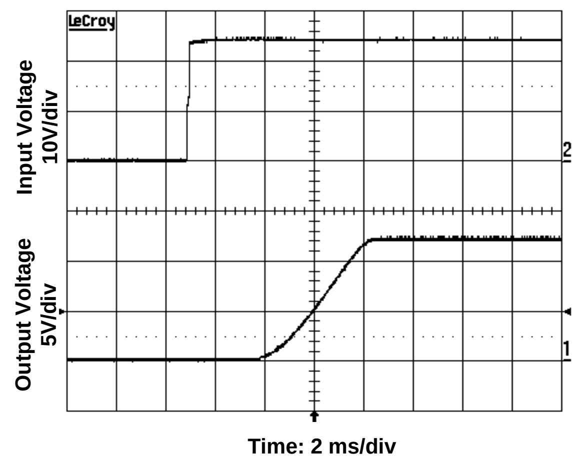


Figure 5. Start-Up from Application ofInput Voltage
Input voltage 24V, Output current 5A, output voltage 12V.

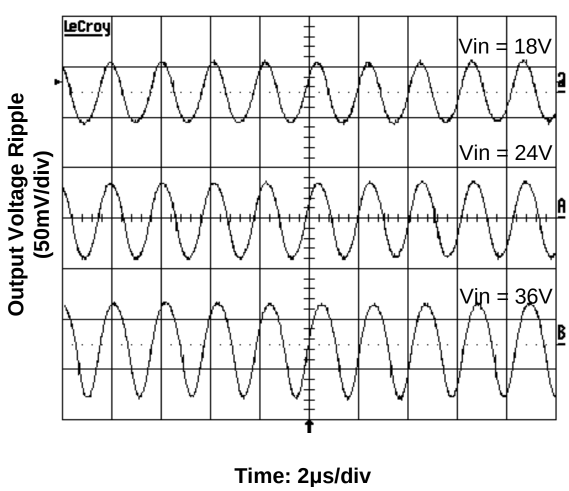


Figure 6. Output Ripple Voltage at 12V, 5A Output

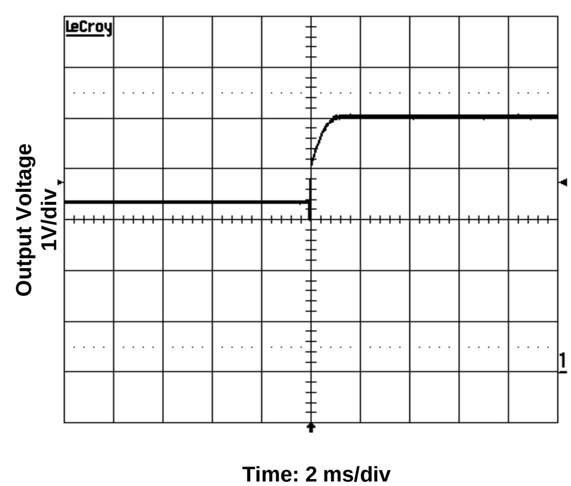
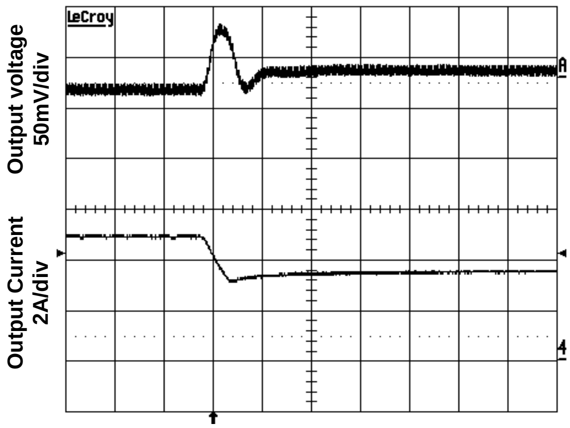
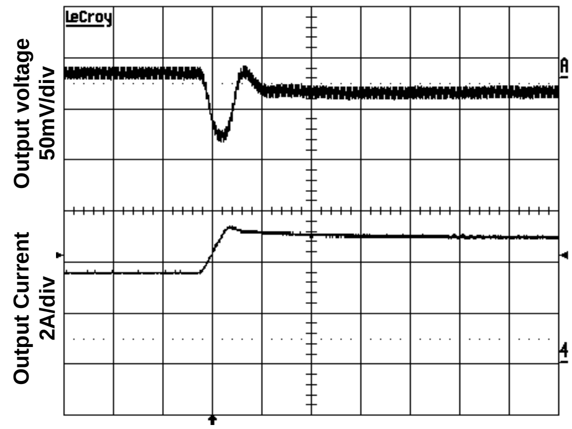


Figure 7. Start-Up with Prebias
Input voltage 24V, Output current 0A, Output voltage 5V, Prebias 3.3V



Time: 50 us/div

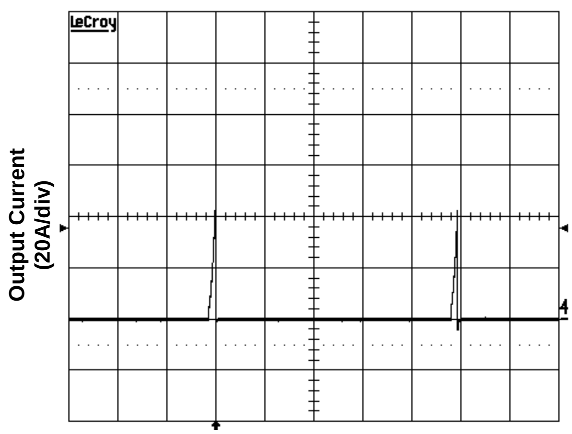
Figure 8. Transient Load Response
Input/output voltage 24/12V, Output current 5A->3.75A,Slew rate 0.1A/µs.



Time: 50 us/div

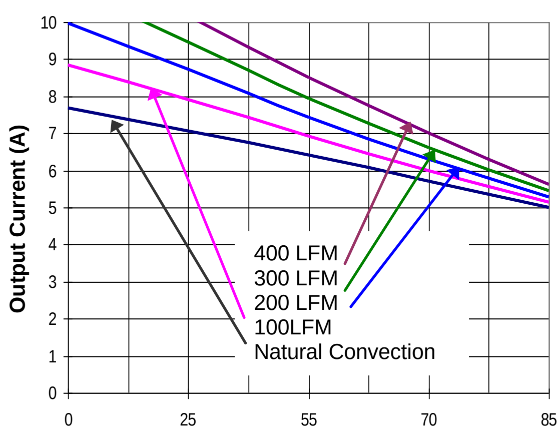
Figure 9. Transient Load Response

Input/output voltage 24/12V, Output current 3.75A->5A, Slew rate 0.1A/µs .



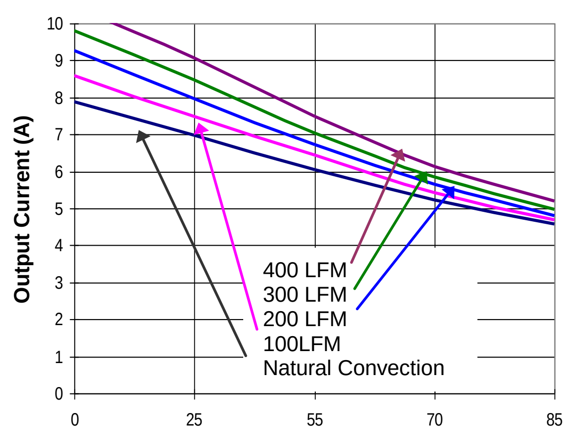
Time: 10 ms/div

Figure 10. Short Circuit Current. Vin = 24V



Ambient Temperature(°C)

Figure 11. Current Derating Curve for 5V Output
(Vin = 24V open frame)



Ambient Temperature(°C)

Figure 12. Current Derating Curve for 12V Output
(Vin = 24V open frame)

Feature Descriptions

Remote ON/OFF

The converter can be turned on and off by changing the voltage or resistance between the ON/OFF pin and GND. The NAT converters can be ordered with factory selectable positive logic or negative enabling logic.

For the negative control logic, the converter is ON when the ON/OFF pin is at a logic low level, and OFF when the ON/OFF pin is at a logic high level. With positive control logic, the converter is ON when the ON/OFF pin is at a logic high level and OFF when the ON/OFF pin is at a logic low level.

With the internal pull-up circuitry, a simple external switch between the ON/OFF pin and GND can control the converter. A few example circuits for controlling the ON/OFF pin are shown in Figures 13, 14 and 15.

The logic-low level is from 0V to 1.2V, and the maximum switch current during logic low is 1mA. The external switch must be capable of maintaining a logic-low level while sinking this current. The maximum ON/OFF pin voltage, generated by the converter internal circuitry for logic-high level, is less than 10V. The maximum allowable leakage current from this pin at logic-high level is 50μA.

When the ON/OFF pin is left unconnected (floating), the converter is enabled.

Remote SENSE

The remote SENSE pin is used to sense voltage at the load point to accurately regulate the load voltage and eliminate the impact of the voltage drop in the power distribution path.

The SENSE pin should be connected to the point where regulation is desired. The voltage difference between the output pins must not exceed the operating range of this converter shown in the specification table.

When remote sense is not used, the SENSE pin can be connected to the positive output terminals. If the SENSE pins are left floating, the converter will deliver an output voltage slightly higher than its specified typical output voltage. The OVP (output over-voltage protection) circuit senses the voltage across the output pins, so the total voltage rise should not exceed the minimum OVP setpoint given in the Specifications Table in operation.

Because the converter does not have remote sense connection for GND or power return path, it is important to make sure that the connection resistance and voltage drop between GND pins and the load is small. It's also advisable to connectthe multiple GND pins with low resistance traces.

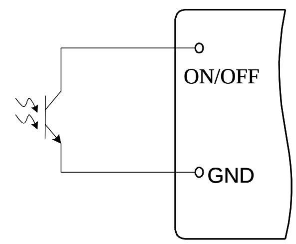


Figure 13. Opto-Coupler Enable Circuit

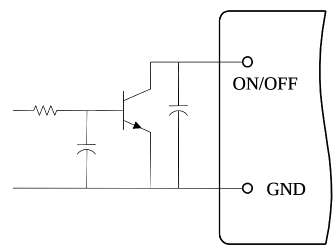


Figure 14. Open Collector Enable Circuit

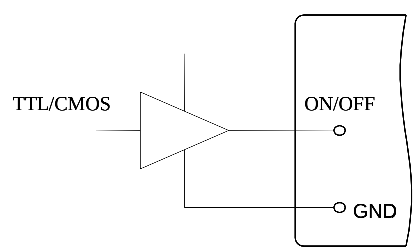


Figure 15. Direct Logic Drive

Output Voltage Programming and Adjustment

The output voltage of this converter is preset to 5.021V as a default. Customers can also order 12V or 15V as the preset voltage by indicating the desired voltage in the part number. The output voltage be trimmed up to 15.5V using an external trim resistor. To trim the voltage lower than the preset voltage, an external voltage higher than the nominal voltage has to be applied to the Trim pin.

The trim pin allows the user to adjust the output voltage set point with an external resistor or voltage. If the trim pin is open, the converter outputs preset voltage. If the trim pin is shorted to GND, the converter outputs 15.521V. To program the output voltage, a resistor should be connected between the Trim pin and the GND pin. The output voltage can be adjusted down by changing the value of the external resistor using the equation below:

$$R_{trim} = \left(\frac{10.5}{\Delta} - 1\right) \quad (k\Omega)$$

Where,

$$\Delta = V_o - V_{o,nom}$$

$$V_{o,nom} = 5.021 \text{ (Default preset output voltage)}$$

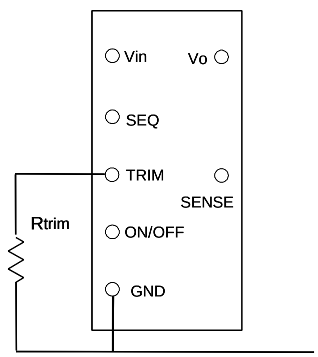


Figure 16. Circuit to Trim Output Voltage

The circuit configuration for trim operation is shown in Figure 16. Because NAT converters use GND as the reference for control, R_{trim} should be placed as close to GND pin as possible, and the trace connecting GND pin and R_{trim} should not carry significant current, to reduce the effect of voltage drop on the GND trace/plain on the output voltage accuracy.

When use remote sense and trim functions simultaneously, do not allow the output voltage at the converter output terminals to be outside the operating range.

Input Under-Voltage Lockout

This feature prevents the converter from turning on until the input voltage reaches about 17V.

Output Over-Current/Short-Circuit Protection

This converter is designed to operate within 9A of output current. The converter turns off when the load current exceeds the current limit. If the over-current or short circuit condition persist, the converter will operate in a hiccup mode (repeatedly trying to restart) until the over-current condition is cleared.

Thermal Shutdown

As a standard feature, the converter will shut down if an over-temperature condition is detected. The converter has a temperature sensor located within the converter's circuit board, which detects the thermal condition of key components of the converter.

The thermal shutdown circuit is designed to turn the converter off when the temperature at the sensor reaches 120°C. The converter will resume operation after the converter cools down.

Output Over-Voltage Protection

As an optional feature, if the voltage across the output pins exceeds the output voltage protection threshold as shown in the Specifications Table, the converter will clamp the output voltage to protect the converter and the load. The converter automatically resumes normal operation after the over voltage condition is removed.

The typical over-voltage protection setpoint for this converter is 25% higher than nominal output, or 18.75V for adjustable output models.

Voltage Tracking/Sequencing

An optional voltage tracking/sequencing feature is available with this converter for output voltage up to 8V. This feature is compatible with the "Voltage Sequencing" feature (DOSA) or the "Voltage Tracking" feature (POLA) seen in industry standards. If this feature is not used, the corresponding SEQ pin should be left open, or tied to a voltage higher than the output voltage but less than 10V.

The tracking feature is not available when output voltage is higher than 8V.

This feature basically forces the output of the converter to follow the voltage at the SEQ pin until it reaches the setpoint during startup, or is completely shutdown during turnoff. The converter's output voltage is controlled to be the same magnitude as the voltage on the SEQ pin, on a 1:1 basis. When using this function, one should pay careful attention to the following aspects:

1) This feature is intended mainly for startup and shutdown sequencing control. In normal operation, the voltage at SEQ pin should be maintained higher than the required output voltage, or the SEQ pin is left unconnected;
2) The input voltage should be valid for this feature to work. During startup, it is recommended to have a delay of at least 10 ms between the establishment of a valid input voltage, and the application of a voltage at the SEQ pin;
3) The ON/OFF pin should be in "Enabled" state when this function is effective.
4) The converter's pre-bias startup is affected by this function. The converter will still be able to start under a pre-bias condition, but the output voltage waveform will have a glitch during startup.

Frequency Synchronization

When multiple converters are used in a system, it is desirable to have all converters running at the same switching frequency to avoid the so-called "beat frequency" phenomenon, and reduce the system noise. The switching frequency of this series of POL converters can be synchronized to an outside clock with a frequency at least 10-20 kHz higher than the maximum free-running switching frequency of the converter. For example, for converters with a nominal switching frequency of 300 kHz, the minimum frequency of the synchronous clock should be at least 340 kHz. With the use of synch clock, the under-voltage lock-out (UVLO) point of the converter becomes higher. The Higher the synch frequency is, the higher UVLO becomes. Please contact NetPower if the UVLO point is to remain unchanged with a given synch frequency. The following table shows a relationship between synch frequency and UVLO on a 300 kHz converter:

Synch Freq. (kHz)	340	380	420	460	500	540	580	620	660	700
UVLO (V)	9.5	10	11	11.4	12.1	12.7	14	14	14.8	15.5

The key parameters of the clock signalare: pulse width at least 50nS, logic HIGH level in 2 - 5V, logic LOW level less than 0.8V, and being able to source and sink at least 10 μA current. The clock signal should be connected to the optional PIN B (SEQ pin), which is also used for the optional voltage sequencing (tracking) pin. Therefore, the voltage tracking function and the frequency synchronization function can not be selected at the same time. This pin can be left open or shorted to GND if the synch function is not used.

The effective edge of the synchronization pulse is the falling edge of the clock signal. Through properly phase-shift of the clock signals, multiple converters can work in an interleaved manner, reducing the strength of the switching noise.

Design Considerations

Input Source Impedance and Filtering

The stability of the NAT converters, as with any DC/DC converter, may be compromised if the source impedance is too high or too inductive. It's desirable to keep the input source AC impedance as low as possible. To reduce switching frequency ripple current getting into the input circuit (especially the ground/return conductor), it is desirable to place some low ESR capacitors at the input. Ceramic capacitors of at least 10uF total capacitance are recommended. Due to the existence of inductance (such as the trace inductance, connector inductance, etc.) in the input circuit, possible oscillation may occur at the input of the converter. Because the relatively high input current of low input voltage power system, it may not be practical or economical to have separate damping or soft start circuit in front of POL converters. We recommend to use a combination of ceramic capacitors and Tantalum/Polymer/Aluminum capacitors at the input, so the relatively higher ERS of Tantalum/Polymer capacitors can help damp the possible oscillation between the ceramic capacitors and the inductance.

Similarly, although the converter is designed to be stable without external capacitor at the output, some low ESR capacitors at the output may be desirable to further reduce the output voltage ripple or improve the transient response. Again, a combination of ceramic capacitors and Tantalum/Polymer/Aluminum capacitors usually can achieve good results.

Safety Considerations

To meet safety requirements of the system, the converter shall be used in accordance with the requirements of end-use equipment safety standards. If a fuse is to be used at the input, it's recommended to use a fast blow fuse with adequate current rating.

The converter's output meets SELV requirements if its input meets SELV requirements.

Thermal Considerations

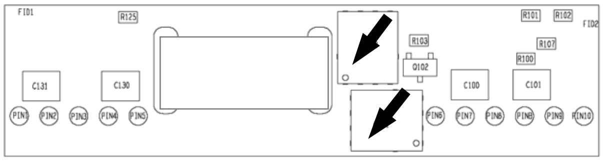


Figure 17.Temperature Monitoring Locations

The NAT converters can operate in various thermal environments. Due to the high efficiency and optimal heat distribution, these converters exhibit excellent thermal performance. Proper cooling in the end system can be verified by monitoring the temperature of the key components. Figure 17 shows recommended temperature monitoring points. The temperature at these locations should not exceed 120 °C continuously.

The maximum allowable output power of any power converter is usually determined by the electrical design and the maximum operating temperature of its components. The NAT converters have been tested comprehensively under various conditions to generate the derating curves with consideration for long term reliability.

Thermal derating curves are highly influenced by derating guide, the test conditions and test setup, such as test temperatures, the interface method between the converter and the test fixture board, spacing and construction (especially copper weight, holes and openings) of the fixture board and the spacing board, temperature measurement method, and the ambient temperature measurement point. The thermal derating curves in this datasheet are obtained by thermal tests in a windtunnel at 25ºC, 55ºC, 70ºC, and 85ºC. The converter's power pins are soldered to a 2-layer test fixture board through 18 AWG wires. The space between the test board and a PWB spacing board is 1". Usually, the end system board has more layer count, and has better thermal conduction than our test fixture board. For thermal considerations specific to your application environment, please contact NetPower's technical support team for assistance.

Heat Transfer without a Baseplateor Heatsink

Convection heat transfer is the primary cooling means for converters without a baseplate. Therefore, airflow speed is important for any intended operating environment. Increasing the airflow over the converter enhances the heat transfer via convection.

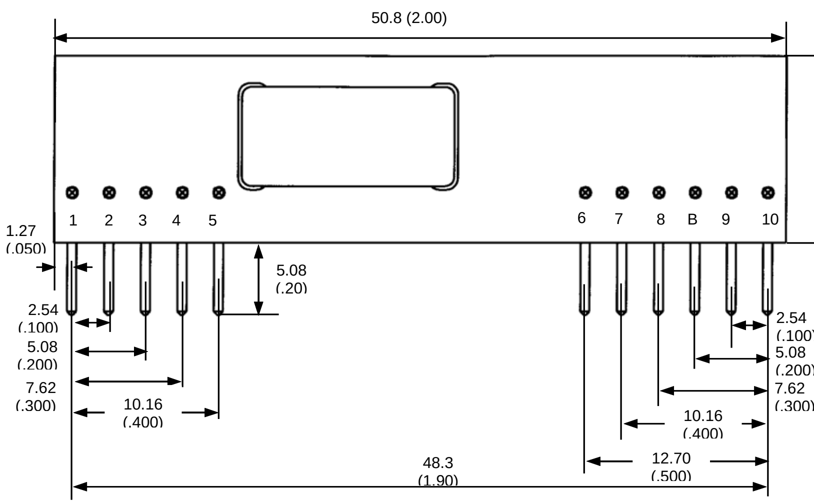
Figures 11and 12 show the current derating curves under nominal input voltage for a few output voltages. To maintain long-term reliability, the module should be operated within these curves in steady state. Note: the natural convection condition can be measured from 0.05 - 0.15 m/s (10 - 30 LFM).

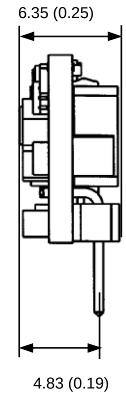
Heat Transfer with a Baseplate or Heatsink

The NAT converter can use a baseplate to further enhance their thermal performance. A baseplate works as a heat spreader, and thus can improve the heat transfer between the converter and its ambient.

An additional heatsink or cold-plate can be attached to the baseplate with external mechanical attachment. The heatsink/cold plate further improves the thermal performance of the converter.

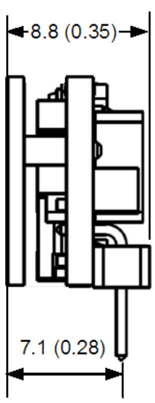
Mechanical Information





All pins:
0.635(0.025'')

Pin#	1	2	3	4	5	6	7	8	B	9	10
Function	Vo	Vo	Sense	Vo	GND	GND	Vin	Vin	SEQ	Trim	ON/OFF



Side View with Baseplate

Notes

1) All dimensions in mm (inch) (1 inch = 25.4mm).Tolerances:
   .x (.xx):±0.5 (0.020'')
   .xxx:±0.25 (0.010'')
2) All pins are 0.635mm (0.025") square.
3) A converter's thickness is increased to 0.35'' with a baseplate option.
3) All pins are coated with 90%/10% solder finish, or Matte Tin, or Gold.
4) Weight: 7 g open frame converter
5) Workmanship: Meet or exceeds IPC-A-610 Class II
6) Baseplate flatness tolerance is 0.10mm (0.004") TIR for surface.