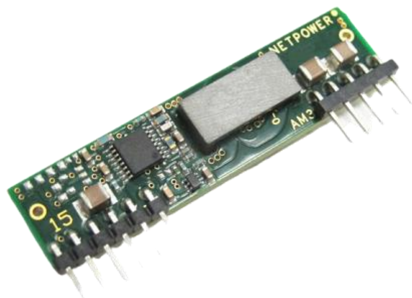
0.75-5.5V 20A SIP Point-of Load Converter



Features

- Efficiency up to 93.0% (5V/20A)
- Excellent thermal performance
- Remote ON/OFF
- Output remote sense, output trim
- Output over-voltage, over-current, short-circuit and over-temperature protections
- Monotonic start-up into pre-biased load
- UL 60950-1 2nd edition recognized†

Options

- Baseplate
- Negative / Positive enable logic
- Output voltage protection
- Output voltage tracking / Sequencing
- Switching frequency synchronization

Part Numbering System

NAT	1	000	□	20	R	□	□
Series Name	**Input Voltage**	**Output Voltage**	**Enabling Logic**	**Rated Output Current**	**Pin Length**	**Electrical Options**	**Mechanical Options**
	1: 8.5-18V	**000:** Variable* (0.75-5.5V)	**P:** Positive **N:** Negative	**Unit:** A **20:** 20A	**R:** 0.20”	**0:** Default **1:** Voltage Tracking (VT) **2:** OVP **3:** VT & OVP **4:** Synchronization (Sync) **5:** Sync & OVP	**5:** Open frame **6:** Baseplate

** Consult the factory for semi-custom codes with the output voltage set to a specific value without using an external programing resistor.*

† UL is a registered trademark of Underwriters Laboratory Inc.

Absolute Maximum Rating

Excessive stresses over these absolute maximum ratings can cause permanent damage to the converter. Operation should be limited to the conditions outlined under the Electrical Specification Section.

Parameter	Min	Max	Unit
Input Voltage (continuous)	-0.5	22	V
Operating Ambient Temperature (See Thermal Considerations section)	-40	85*	˚C
Storage Temperature	-55	125	˚C

**Derating curves provided in this datasheet end at 85ºC ambient temperature. Operation above 85ºC ambient temperature is allowed provided the temperatures of the key components or the baseplate do not exceed the limit stated in the Thermal Considerations section.*

Electrical Specifications

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

Parameter		Min	Typical	Max	Unit
Input Specifications					
Input Voltage		8.5	12.0	18.0	V
Input Current		-	-	10	A
Quiescent Input Current (typical Vin)		-	120	200	mA
Standby Input Current		-	2	-	mA
Input Reflected-ripple Current, peak-to-peak (5-20 MHz, 12µH source impedance)		-	20	-	mA
Input Turn-on Voltage Threshold		-	8.3	-	V
Output Specifications					
Output Voltage Set Point Accuracy (typical Vin; full load; Ta = 25°C)		-2.0	-	+2.0	%Vo
Output Voltage Set Point Accuracy (over all conditions)		-2.5	-	+3.5	%Vo
Output Regulation: Line Regulation (full range input voltage, 1/2 full load) Load Regulation(full range load, typical Vin) Temperature (Ta = -40°C to 85 °C)		 - - -	 0.2 0.3 0.2	 - - -	%Vo
Output Ripple and Noise Voltage RMS Peak-to-peak (5 Hz to 20 MHz bandwidth, typical Vin)		 - -	 - 1.5	 1 -	%Vo
Output Current		0	-	20	A
Efficiency (typical Vin; full load; Ta = 25°C)	Vo=0.8V	-	73.0	-	%
	Vo=1.0V	-	78.0	-	
	Vo=1.2V	-	81.0	-	
	Vo=1.5V	-	84.0	-	
	Vo=1.8V	-	85.5	-	
	Vo=2.5V	-	88.5	-	
	Vo=3.3V	-	91.0	-	
	Vo=5V	-	93.0	-	
Output Over Current Protection Set Point		-	200	-	%
Output Over Voltage Protection Set Point		115	125	135	%

Output Ripple Frequency	270	300	330	kHz
External Load Capacitance	-	-	5,000	µF
Dynamic Response (typical Vin; Ta = 25°C; load transient 0.5A/µs) Load steps from 50% to 100% of full load: Peak deviation Settling time (within 10% band of Vo deviation) Load step from 100% to 50% of full load Peak deviation Settling time (within10% band of Vo deviation)	 - - - -	 200 70 200 70	 - - - -	 mV µs mV µs
General Specifications				
Remote Enable Logic Low: ION/OFF = 1.0mA VON/OFF = 0.0V Logic High: ION/OFF = 0.0µA Leakage Current	 0 - 3.5 -	 - - - -	 0.5 1.0 Vin, max. 50	 V mA V µA
Calculated MTBF (Telecordia SR-332, 2011, Issue 3), full load, 40°C, 60% upper confidence level, typical Vin	-	11.7	-	10^6-hour

Characteristic Curves

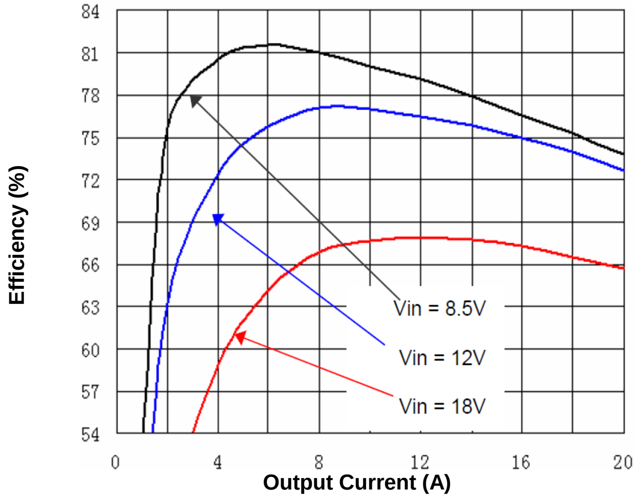


Figure 1a. Efficiency vs. Load Current (25°C, Vo=0.8V)

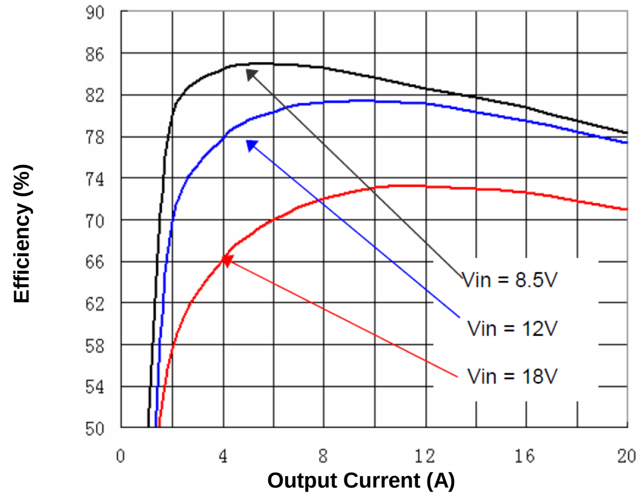


Figure 1b. Efficiency vs. Load Current (25°C, Vo=1.0V)

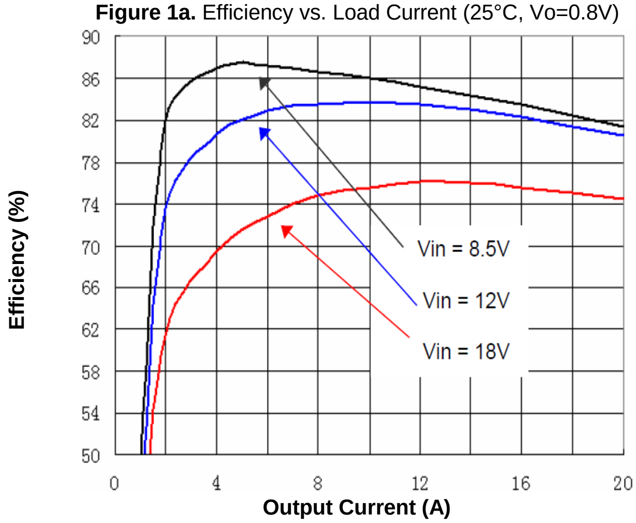


Figure 1c. Efficiency vs. Load Current (25°C, Vo=1.2V)

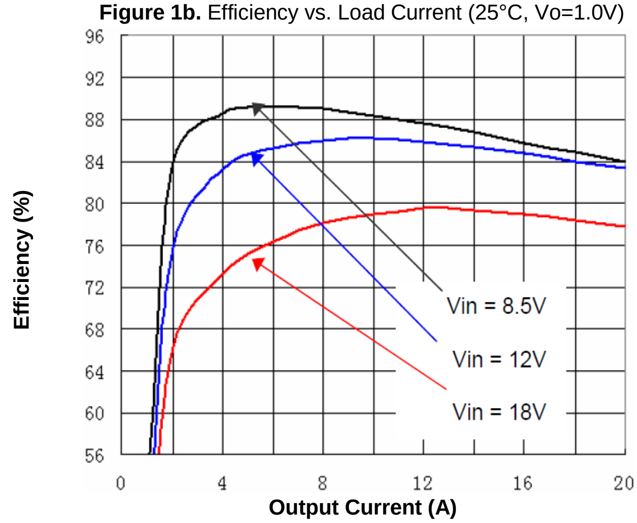


Figure 1d. Efficiency vs. Load Current (25°C, Vo=1.5V)

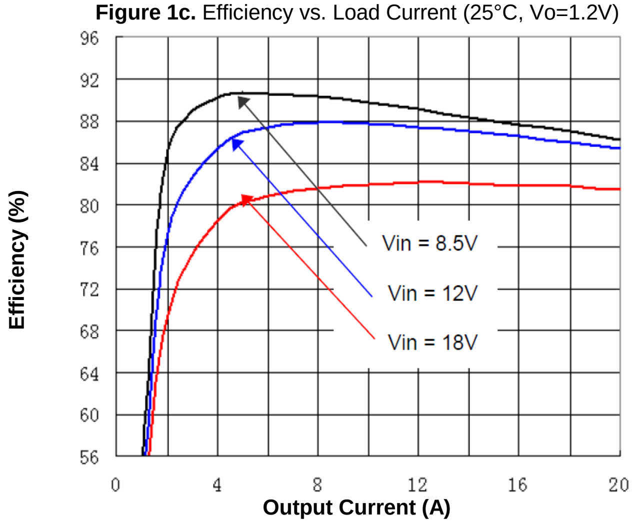


Figure 1e. Efficiency vs. Load Current (25°C, Vo=1.8V)

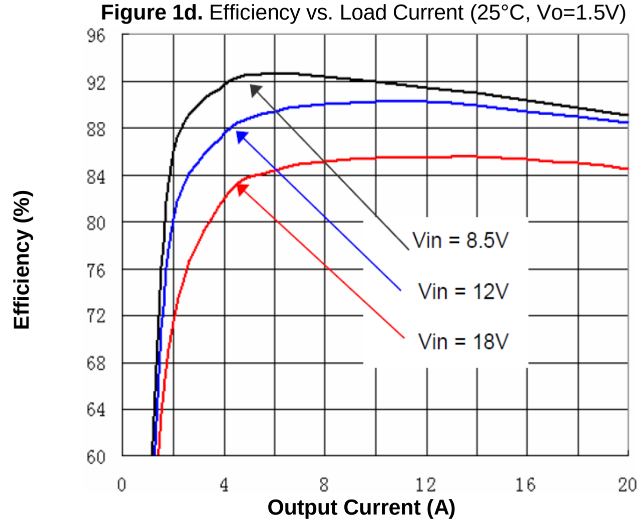


Figure 1f. Efficiency vs. Load Current (25°C, Vo=2.5V)

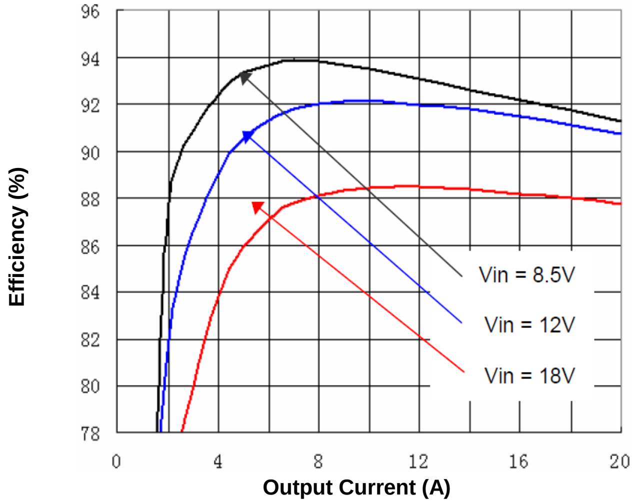


Figure 1g. Efficiency vs. Load Current (25°C, Vo=3.3V)

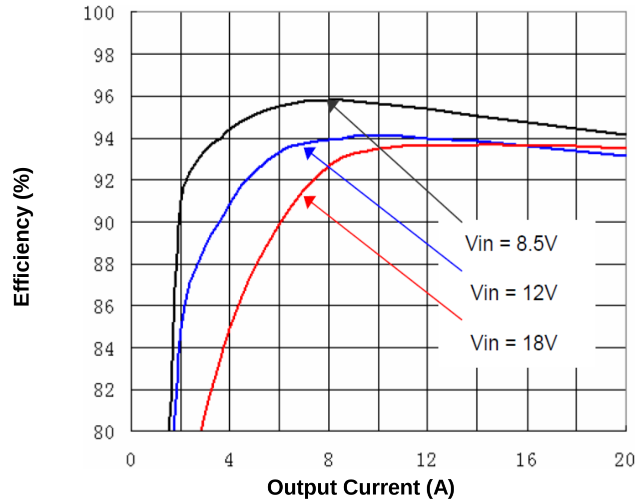


Figure 1h. Efficiency vs. Load Current (25°C, Vo=5V)

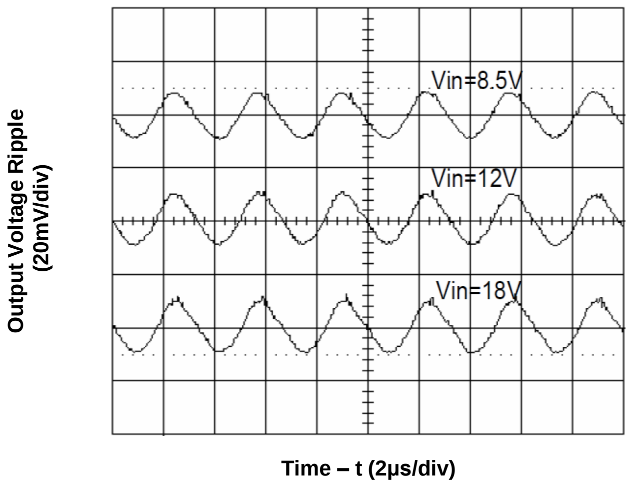


Figure 2. Output Ripple Voltage (2.5V/20A output)

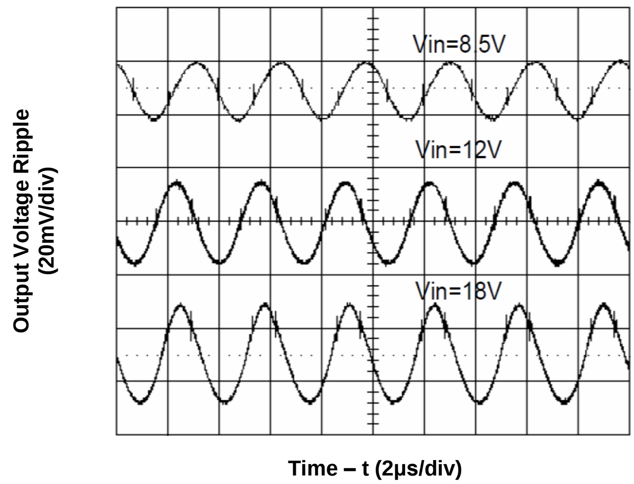


Figure 3. Output Ripple Voltage (5V/20A output)

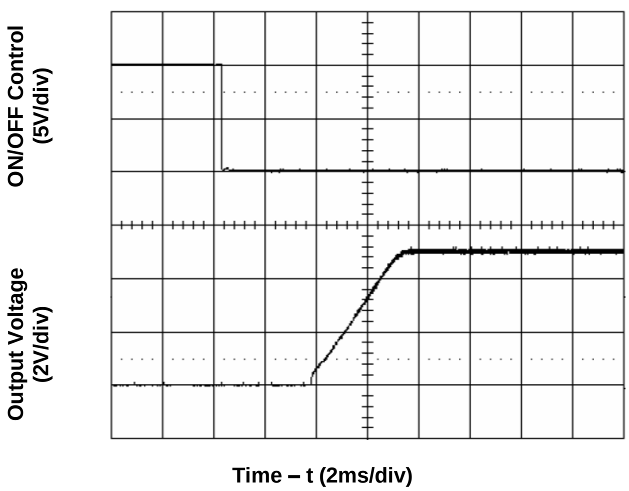


Figure 4. Start-Up from Enable Control
(Vin=12V, zero load)

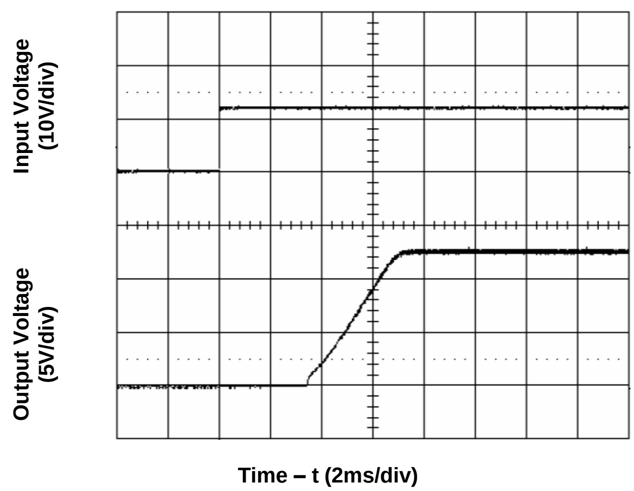
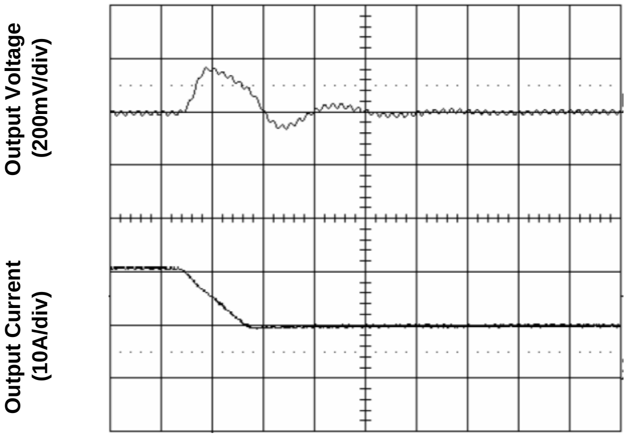
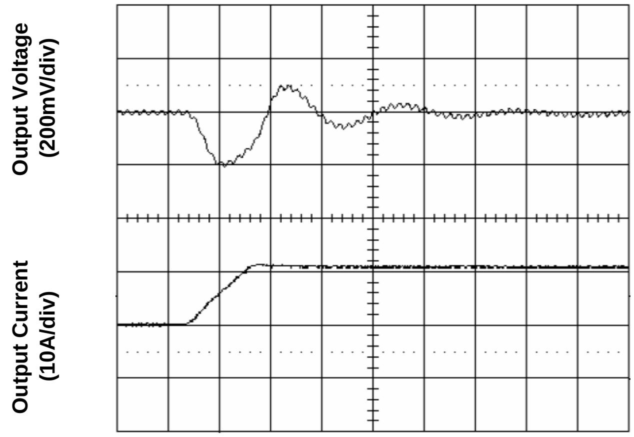


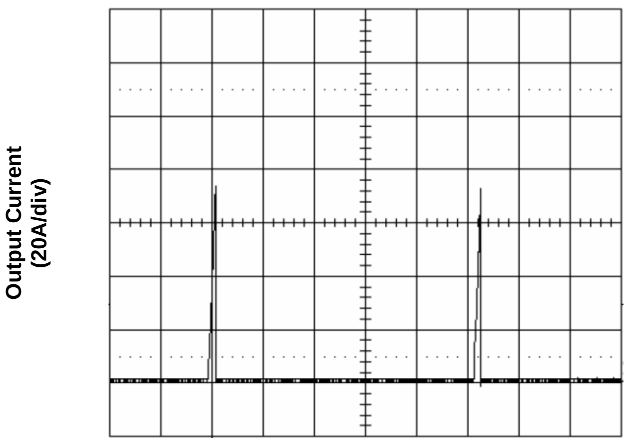
Figure 5. Start-Up from Application of Input Voltage
(Vin=12V, zero load)



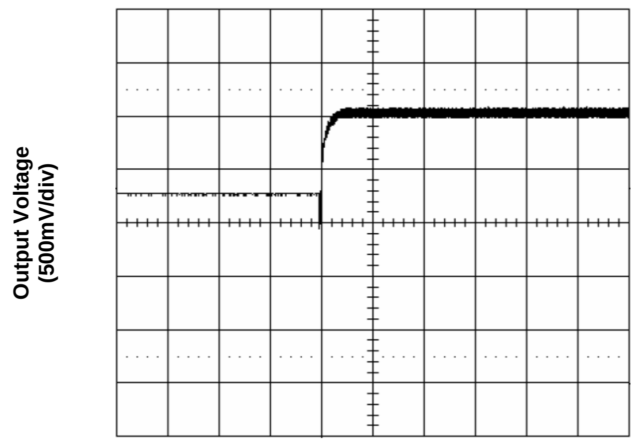
Time – t (200µs/div)
Figure 6. Transient Load Response
(Vin=5V, load current steps from 100% to 50% at a slew rate 0.5A/µs)



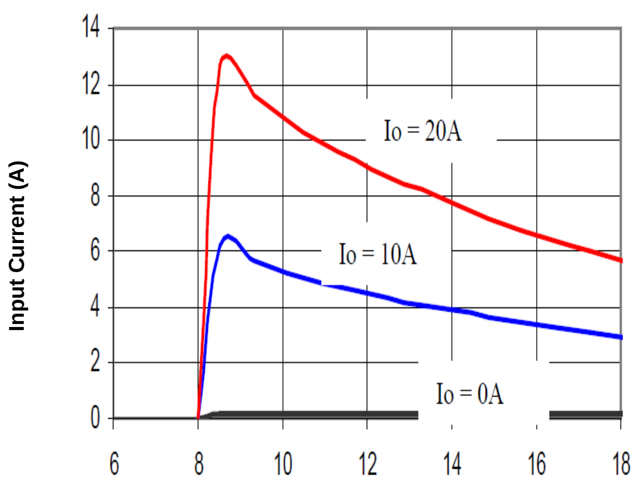
Time – t (200µs /div)
Figure 7. Transient Load Response
(Vin=5V, load current steps from 50% to 100% at a slew rate 0.5A/µs)



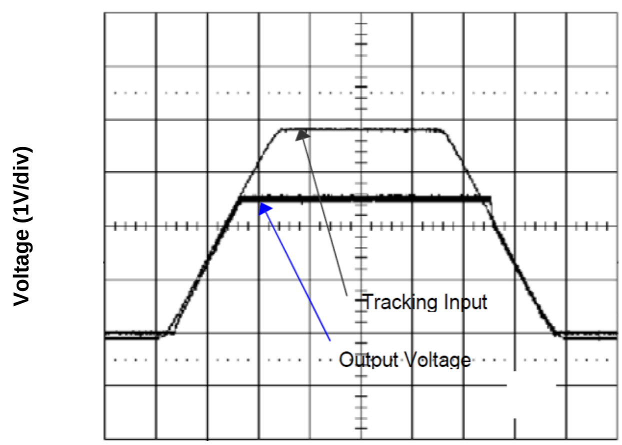
Time – t (10ms/div)
Figure 8. Short Circuit Current at Full Load



Time – t (2ms/div)
Figure 9. Start-Up with Pre-bias
(Vin=12V, 2.5V/0A output, pre-bias voltage=1.2V)



Input Voltage (V)
Figure 10. Input Characteristics (Vo=5V)



Time – t (10ms/div)
Figure 11. Voltage Tracking / Sequencing
(with tracking option, Vin=12V, 2.5V/0A output)

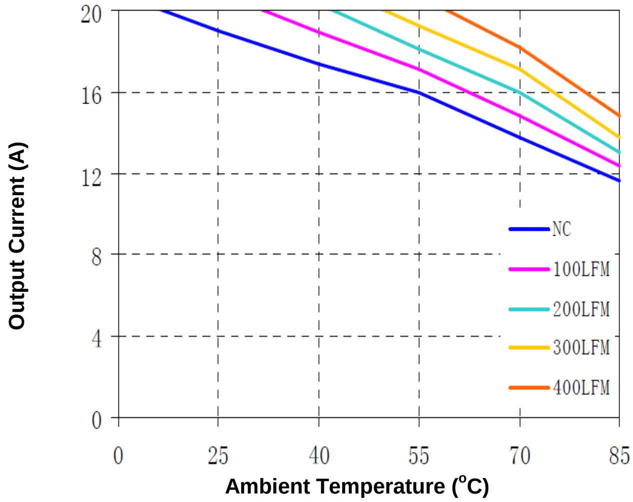


Figure 12a. Current Derating Curve
(Vin=12V, Vo=1.0V, open frame)

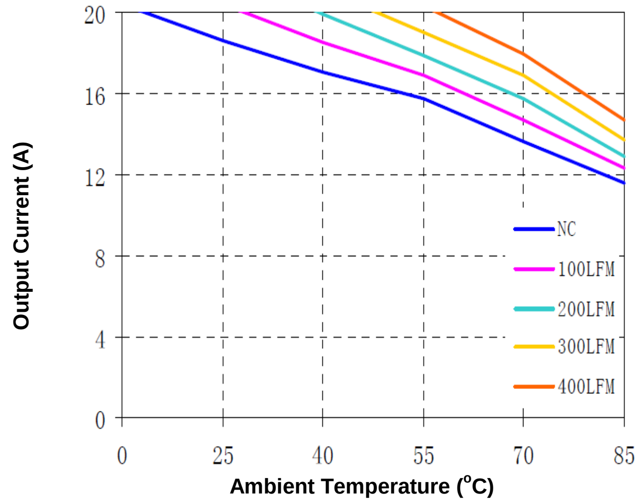


Figure 12b. Current Derating Curve
(Vin=12V, Vo=1.5V, open frame)

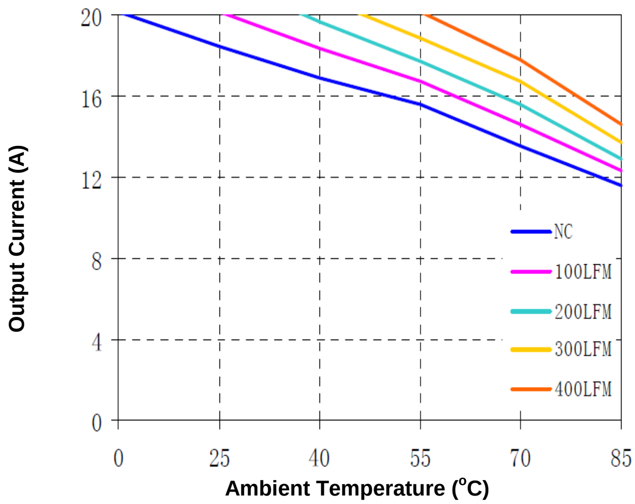


Figure 12c. Current Derating Curve
(Vin=12V, Vo=1.8V, open frame)

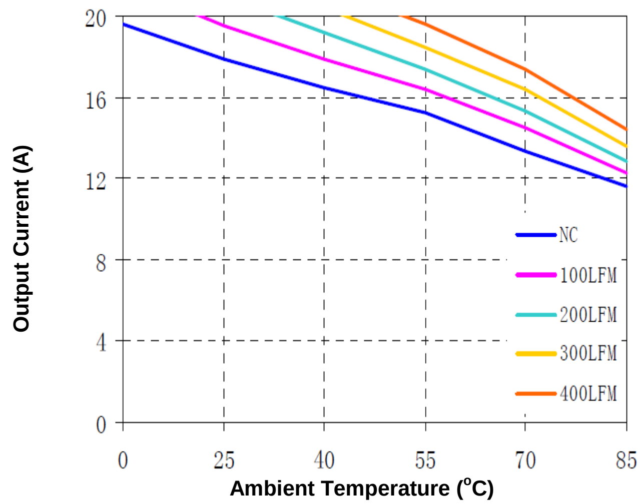


Figure 12d. Current Derating Curve
(Vin=12V, Vo=2.5V, open frame)

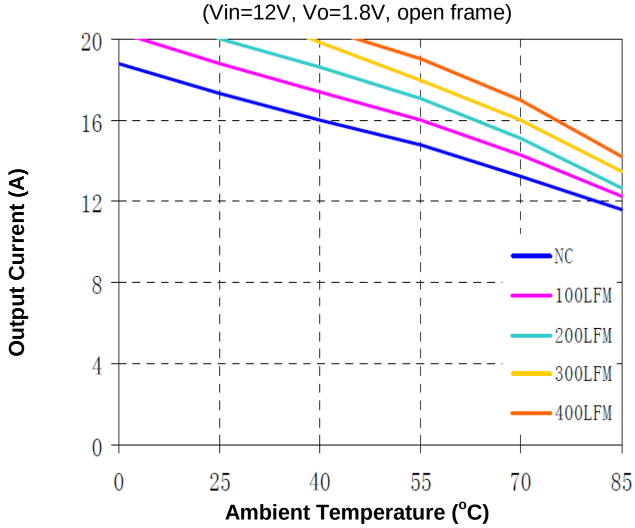


Figure 12e. Current Derating Curve
(Vin=12V, Vo=3.3V, open frame)

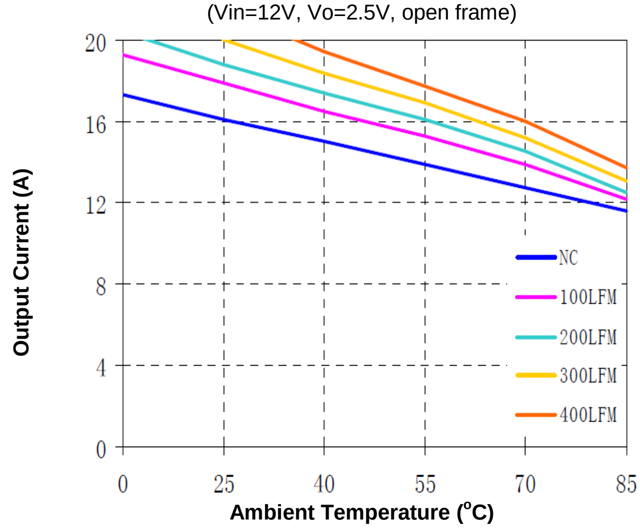


Figure 12f. Current Derating Curve
(Vin=12V, Vo=5V, open frame)

Feature Descriptions

Remote ON/OFF

The converter can be turned on and off by changing the voltage between the ON/OFF pin and GND. The NAT1 series of converters are available with factory selectable positive logic and negative 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. For the 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. The converter is ON no matter what control logic is when ON/OFF pin is left open (unconnected).

Figure 13 is the recommended ON/Off control circuit for positive logic modules, while Figure 14 is for negative logic modules, both using open collector/drain circuit. Recommended value of the pull up resistor R_pull-up is 50Kohm. The maximum allowable leakage current from this pin at logic-high level is 20μA.

The logic low level is from 0V to 0.5V and the maximum sink current during logic low is 2mA. The external switch must be capable of maintaining a logic-low level while sinking up to this current.

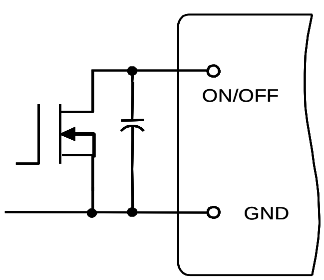


Figure 13. Circuit for Positive Logic Control

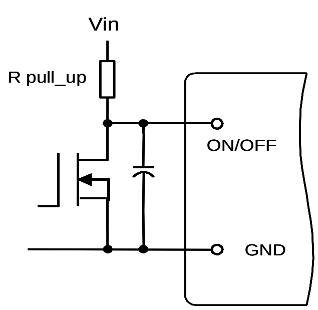


Figure 14. Circuit for Negative Logic Control

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.

Because the converter does not have remote sense connection for the return path, it is important to make sure that the connection resistance and voltage drop between GND pin and the load is small.

Output Voltage Programming and Adjustment

This series of converters are available with variable output voltages. The output voltage is preset to 0.7525V, and can be programmed up to 5.5V using an external trim resistor connected between the Trim pin and GND pin as shown in Figure 15.

The resistance of the external resistor for trimming up the output voltage can be calculated using the equation below:

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

Where

$$\Delta = V_o - V_{onom}$$

For variable output models, V_{onom}=0.7525

Because this converter uses GND as the reference for control, Rtrim should be placed as close to GND pin as possible, and the trace connecting GND pin and Rtrim should not carry significant current, to reduce the effect of voltage drop on the GND trace/plain affecting the output voltage accuracy.

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

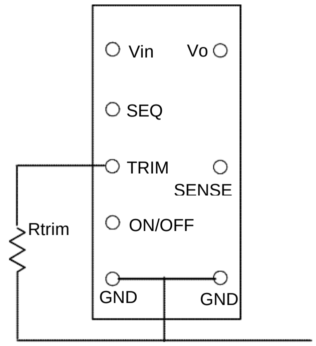


Figure 15. Circuit for Output Voltage Trim

Input Under-Voltage Lockout

This feature prevents the converter from turning on until the input voltage reaches about 8.3V. However, for converters to output higher than 5.5V, the input under-voltage lockout set point is higher and the user should contact the factory for further assistance.

Output Over-Current Protection

As a standard feature, 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, 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.

Output Voltage Tracking / Sequencing

An optional voltage tracking/sequencing feature is available with these converters. This feature is compatible with the “Voltage Sequencing” feature (DOSA) or the “Voltage Tracking” feature (POLA) seen in industry standards.

This feature basically forces the output of the converter to follow the voltage at the SEQ pin until it reaches the set point during startup, or is completely shut down during turn off. 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 output voltage set point.

2). The input voltage should be valid for this feature to work. During startup, it is recommended to have a delay of at least 10ms 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 if this feature is selected.

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 10-20kHz higher than the maximum free-running switching frequency of the converter. For example for converters with a nominal switching frequency of 300kHz, the minimum frequency of the synchronous clock should be at least 340kHz. 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 300kHz 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 signal are: 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 10μA 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

The stability of the NAT1 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 10μF 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

The NAT1 Series of converters is designed in accordance with EN 60950 Safety of Information Technology Equipment Including Electrical Equipment. The converters are recognized by UL in both USA and Canada to meet the requirements in UL 60950, Safety of Information Technology Equipment and applicable Canadian Safety Requirement, and ULc 60950. Flammability ratings of the PWB and plastic components in the converter meet UL94V-0.

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

Thermal Considerations

The NAT1 converters can operate in various thermal environments. Due to high efficiency and optimal heat distribution, these converters exhibit excellent thermal performance.

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 NAT1 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 guideline, the test conditions and 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 wind-tunnel. 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 conductivity than our test fixture board.

Note that the natural convection condition was measured at 0.05 m/s to 0.15 m/s (10ft./min. to 30 ft./min).

Heat Transfer without a Baseplate

Convection heat transfer is the primary cooling means for NAT1 converters. Therefore, airflow speed is important and increasing the airflow over the converter enhances the heat transfer via convection.

The current derating curves for a few output voltages are presented in this datasheet. To maintain long-term reliability, the module should be operated within these curves in steady state.

Proper cooling in the end system can be verified by monitoring the temperature of the key components. Figure 16 shows the recommended temperature monitoring points. The temperature at these locations should not exceed 120 °C continuously.

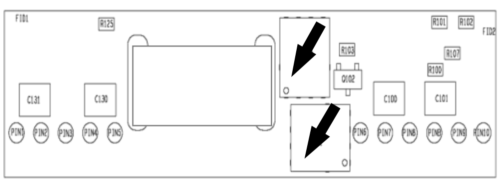


Figure 16. Temperature Monitoring Locations

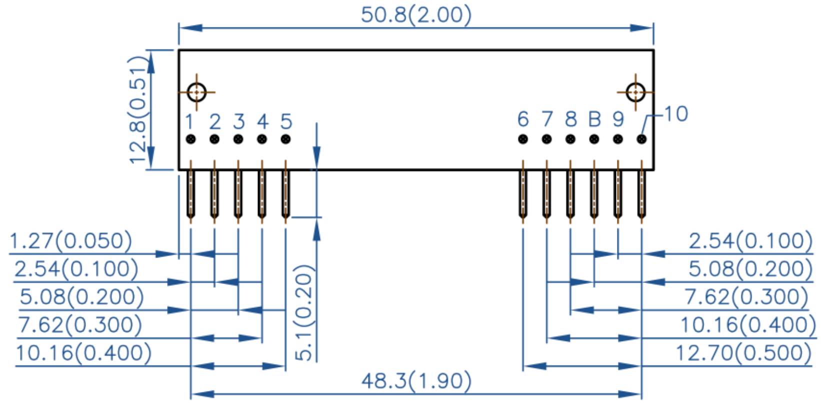
Heat Transfer with a Baseplate

The NAT1 Series of converters have the options of using a baseplate for enhanced thermal performance.

For reliable operation, the baseplate temperature should not continuously exceed 100 °C.

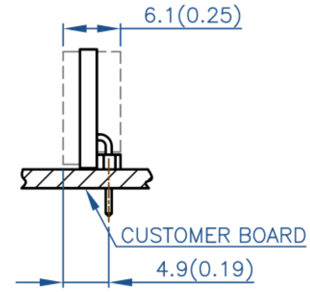
Mechanical Drawing

Open Frame Module



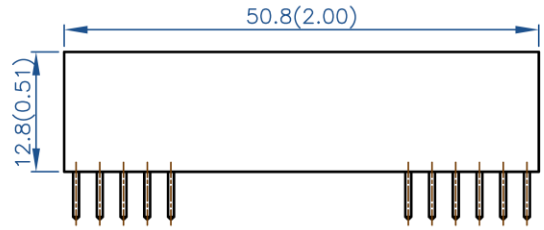
All pins are 0.635 (0.025) square.

TOP VIEW

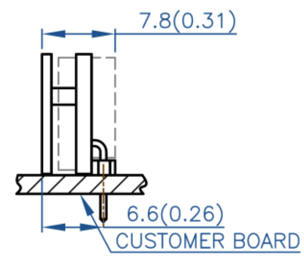


SIDE VIEW

Baseplate Module



TOP VIEW



SIDE VIEW

Pin	Name	Function
1	Vout(+)	Positive output voltage
2	Vout(+)	Positive output voltage
3	SENSE(+)	Positive remote sense
4	Vout(+)	Positive output voltage
5	GND	Power ground
6	GND	Power ground
7	Vin(+)	Positive input voltage
8	Vin(+)	Positive input voltage
B	SEQ	Tracking/Sequencing or Synchronization (optional)
9	TRIM	Output voltage adjustment
10	ON/OFF	Remote control

Notes:

1) All dimensions in mm (inches)
Tolerances: .x ± .5 (.xx ± 0.02)
.xx ± .25 (.xxx ± 0.010)
2) All pins are Copper Alloy, Matte Tin finish with Nickel under plating.
3) Weight: 15.5g open frame converter
18.0g baseplate converter
4) Workmanship: Meet or exceeds IPC-A-610 Class II.
5) Baseplate flatness tolerance is 0.10mm (0.004”) TIR for surface.