NetPower

Leading the Advancement of Power Conversion

28V 25A Full Brick Converter

Features

- High Efficiency: 93.5% (28V/25A)
- Excellent thermal performance
- Output remote sense
- Input under-voltage, output over-voltage, over-current, short-circuit and over-temperature protections
- Monotonic start-up
- Independent 8-12V auxiliary power
- Power Good: Open Collector Output
- Fixed frequency operation
- Basic Insulation, 2,250Vdc input to output isolation
- Designed to meet UL 62368-1 2nd edition

CE

Options

- Baseplate
- Auto-restart / Latch off after fault shutdown
- Negative / Positive enable logic
- Pin lengths

Part Numbering System

FPS	4	280	☐	025	☐	☐	☐
Series Name	Input Voltage	Output Voltage	Enabling Logic	Rated Output Current	Pin Length Options	Electrical Options	Mechanical Options
							Lead-free (ROHS-6 Compliant)
	4: 36-75V	**Unit:** 0.1V **280:** 28V	**P:** Positive **N:** Negative	**Unit:** A **025:** 25A	**K:** 0.110" **N:** 0.145" **R:** 0.180" **J:** 0.240"	**0:** Latch off **2:** Auto-restart	**5:** Open-frame **6:** Baseplate

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	80	Vdc
Input Voltage (< 100ms, operating)	-	100	Vdc
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.

Input Specifications

Parameter	Min	Typical	Max	Unit
Input Voltage	36	48	75	Vdc
Input Current	-	-	30	A
Quiescent Input Current (typical Vin)	-	200	300	mA
Standby Input Current	-	20	100	mA
Input Turn-on Voltage Threshold	34	35	36	V
Input Turn-off Voltage Threshold	33	34	35	V

Output Specifications

Parameter	Min	Typical	Max	Unit
Output Voltage Set Point (typical Vin; full load; Ta = 25°C)	-	28.0	-	V
Output Voltage Set Point Accuracy (typical Vin; full load; Ta = 25°C)	-1	-	+1	%Vo
Output Voltage Set Point Accuracy (over all conditions)	-3	-	+3	%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)	- - -	0.05 - 0.1	0.2 0.2 -	%Vo
Output Ripple and Noise Voltage RMS Peak-to-peak (5 Hz to 20 MHz bandwidth, typical Vin)	- -	- 200	- -	mVrms mVp-p
Output Current	0	-	25	A
Output Power	0	-	700	W
Efficiency (typical Vin; full load, Ta = 25ºC)	-	93.5	-	%
Output Ripple Frequency	200	220	250	kHz
External Load Capacitance	-	-	6,800	µF

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Output Specifications (Continued)

Parameter	Min	Typical	Max	Unit
Startup Delay, duration from enabling signal to Vo reaches 10% of its set point. (typical Vin; full load, Ta = 25ºC)	-	5	-	ms
Startup Time, duration for Vo to rise from 10% of its set point to within its regulation band. ((typical Vin; full load, Ta = 25ºC)	-	25	-	ms
Output Over Current Protection Set Point (full load)	103	-	140	%
Output Over Voltage Protection Set Point (typical Vo)	115	125	135	%
Output Trim Range in % of typical Vo	60	-	115	%
Dynamic Response (typical Vin; Ta = 25°C; load transient 0.1A/µs) Load steps from 50% to 75% of full load: Peak deviation Settling time (within 10% band of Vo deviation) Load step from 75% to 50% of full load Peak deviation Settling time (within10% band of Vo deviation)	- - - -	2 500 2 500	- - - -	%Vo µs %Vo µs
Auxiliary Output Voltage	8	10	12	V
Auxiliary Output Current	-	-	50	mA

General Specifications

Parameter	Min	Typical	Max	Unit
Remote Enable Logic Low: $I_{ON/OFF}$ = 1.0mA $V_{ON/OFF}$ = 0.0V Logic High: $I_{ON/OFF}$ = 0.0µA $V_{ON/OFF}$ = 5V	0 - 2.5 -	- - - -	1.0 0 10 5	V mA V mA
Isolation Capacitance	-	4,700	-	pF
Insulation Resistance	10	-	-	MΩ
Calculated MTBF (Telecordia SR-332, 2011, Issue 3), full load, 40°C, 60% upper confidence level, typical Vin	-	4.4	-	10^6-hour

![NetPower logo] **NetPower**
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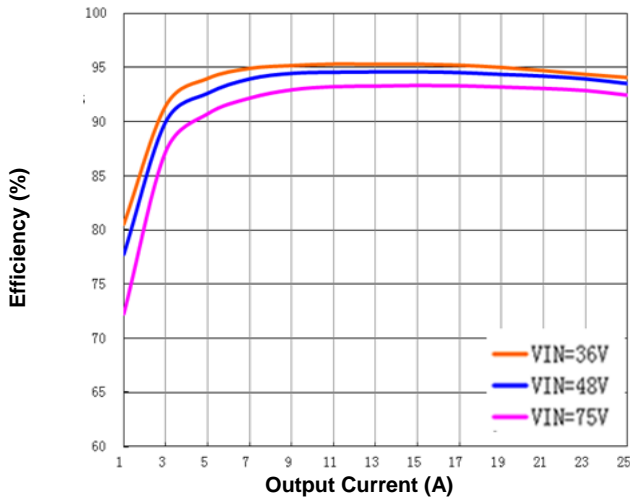
Characteristic Curves

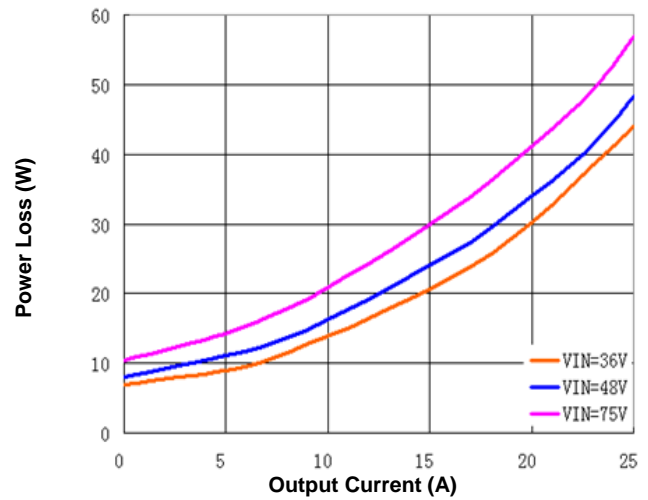**Figure 1.** Efficiency vs. Load Current (25°C)

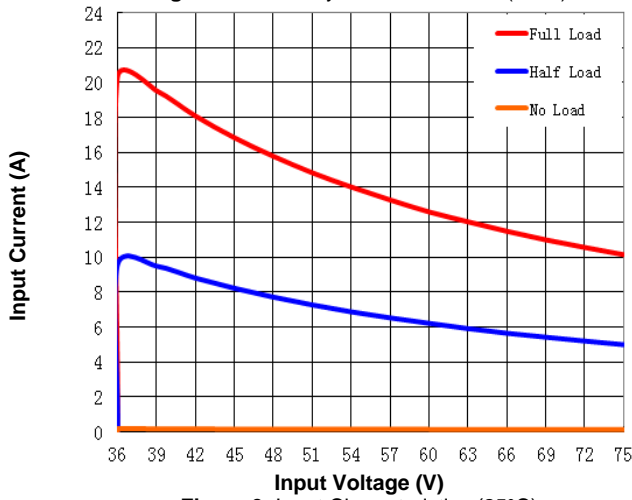**Figure 2.** Power Loss vs. Load Current (25°C)

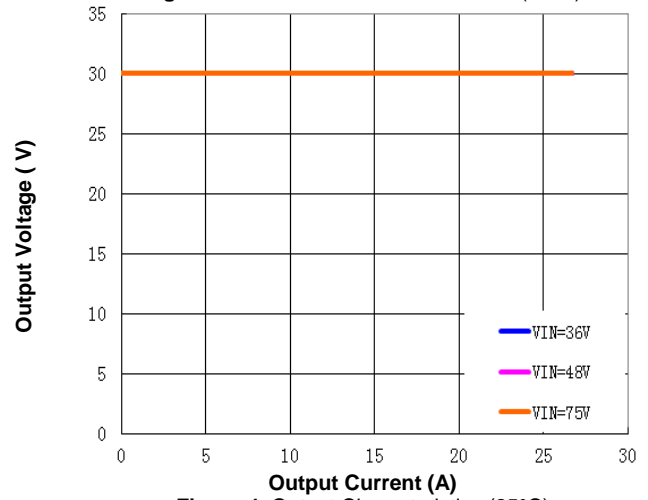**Figure 3.** Input Characteristics (25°C)
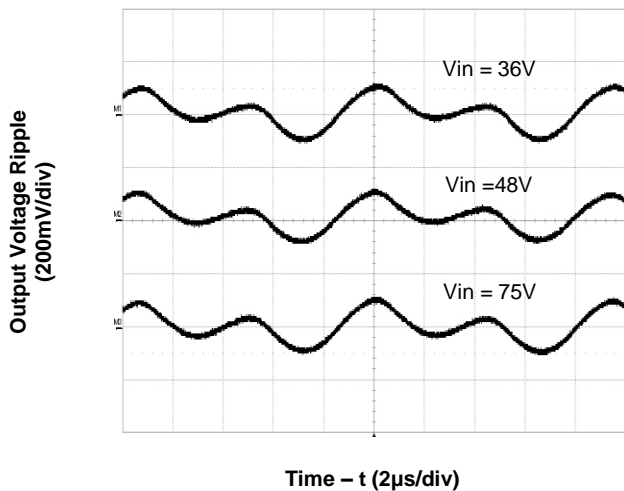

Figure 4. Output Characteristics (25°C)
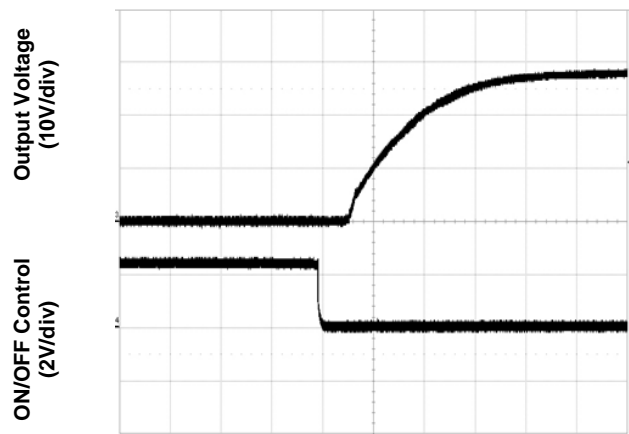

Figure 5. Output Ripple Voltage at Full Load

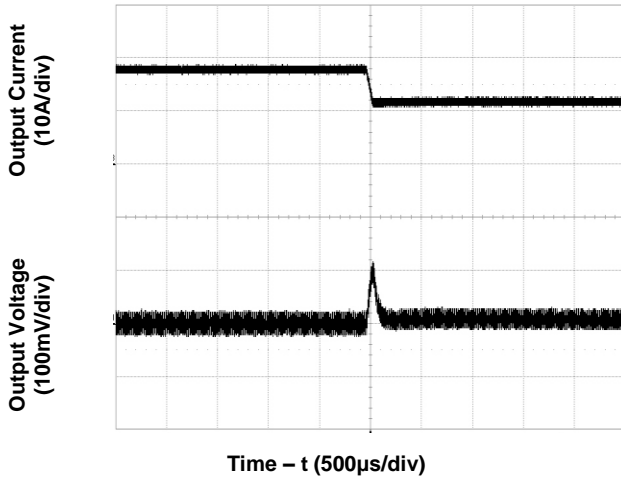**Figure 6.** Start-Up from Enable Control
(typical Vin, full load)

Time – t (500µs/div)
Figure 7. Transient Load Response
(typical Vin, load current steps from 75% to 50% at a slew rate 0.1A/µs)
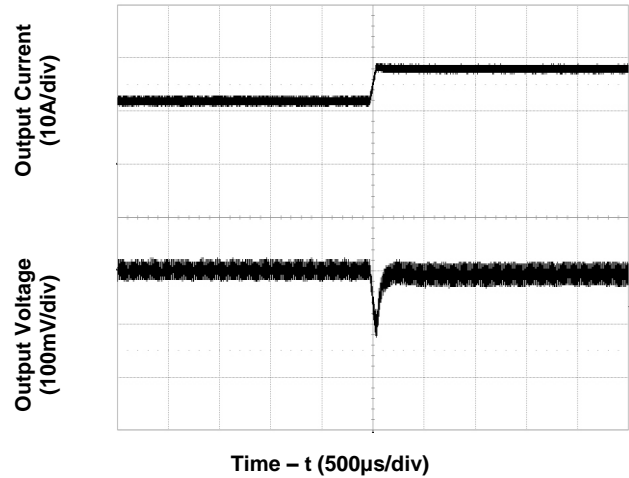

Time – t (500µs/div)
Figure 8. Transient Load Response
(typical Vin, load current steps from 50% to 75% at a slew rate 0.1A/µs)

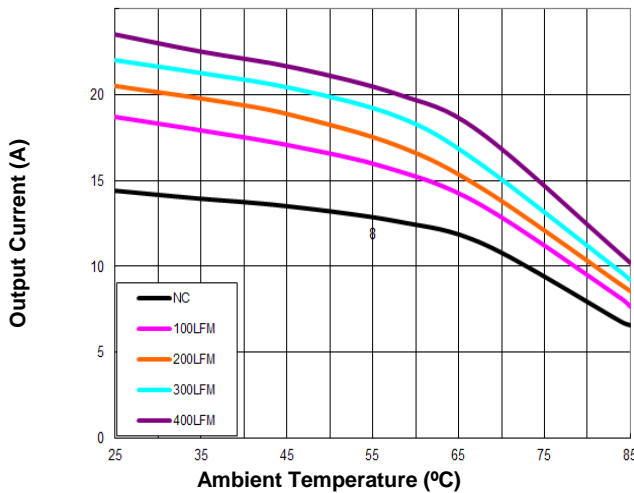**Figure 9.** Current Derating Curve with Open Frame
(Direction 3 (Ref. Figure 10); typical Vin, soldered interface)

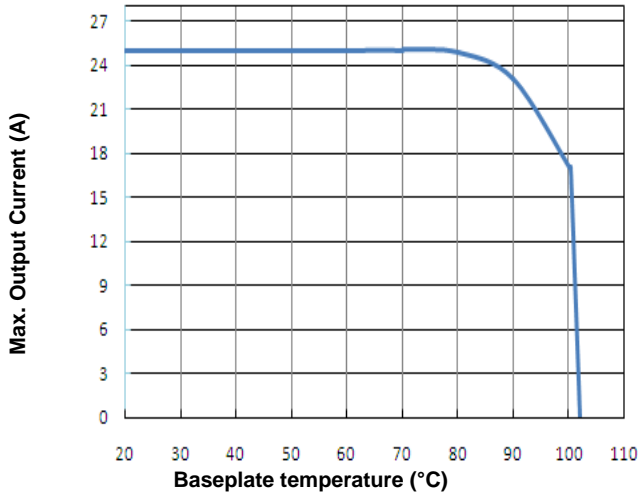**Airflow Direction**

Air Flow

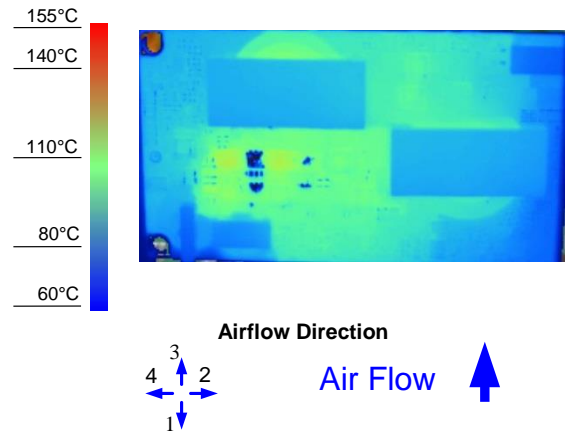**Figure 10.** Thermal Image for Airflow Direction 3
(17.5A output, 55°C ambient, 200 LFM, typical Vin, open frame unit)

Figure 11. Current Derating Curve for Baseplate
(typical Vin with baseplate; solder interface)

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Feature Descriptions

Remote ON/OFF

The remote ON/OFF control circuit is isolated from both the input and the output circuits. The isolation voltage is 1,500Vdc to either the input or the output circuit.

The converter can be turned on and off by changing the voltage applied between the +ON/OFF pin and the -ON/OFF pin. The FPS4 Series converters are available with factory selectable positive and negative logic.

Maximum source current for remote ON/OFF terminal is 5mA. Therefore, set current limiting resistor value such that this maximum source current value is not exceeded. Also, the allowable maximum reverse current flow is 5mA.

Controlling the remote ON/OFF terminal from the input side

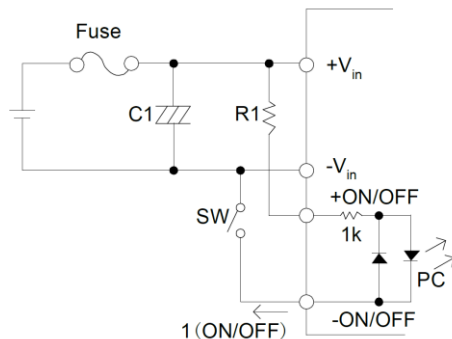Connect current limiting resistor R1 is shown in the following figure 12.

Figure 12. Connection of remote ON/OFF control (A)
R1: Recommended resistor value: 24kΩ (1/2W)

Controlling the remote ON/OFF terminal from the output side

Connect the current limiting resistor R1 is shown in the following figure 13.

When wiring becomes long, connect a capacitor of about 0.1µF value between the +remote ON/OFF terminal and –remote ON/OFF terminal at a nearest distance. Current limiting resistor can also be connected to the –remote ON/OFF terminal side. The positive logic remote control mode is shown in the following table, otherwise it is the negative logic.

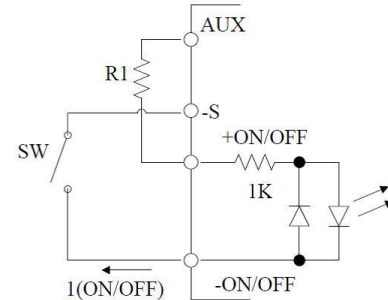| Remote ON/OFF level	Output status
Open (<100µA)	Remote OFF
1.5mA ≤ I (ON/OFF) ≤ 5mA	Remote ON

Figure 13. Connection of remote ON/OFF control (B)
R1: Recommended resistor value: 2kΩ (1/2W)

Remote SENSE

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

SENSE(+) and SENSE(-) pins should be connected to the point where regulation is desired. The voltage between the SENSE pins and the output pins must not exceed the smaller of 0.5V or 10% of typical output voltage.

[Vout(+) - Vout(-)] - [SENSE(+) - SENSE(-)] < MIN {0.5V, 10%Vo}

When remote sense is not used, the SENSE pins should be connected to their corresponding output terminals (positive and negative). If the SENSE pins are left floating, the converter will deliver an output voltage slightly higher than its specified typical output voltage.

Output Voltage Adjustment (Trim)

The trim pin allows the user to adjust the output voltage set point. To increase the output voltage, an external resistor is connected between the Vout(+) and SENSE(+). To decrease the output voltage, an external resistor is connected between the Vout(-) and SENSE(-). The output voltage trim range is 60% to 115% of its specified nominal output voltage.

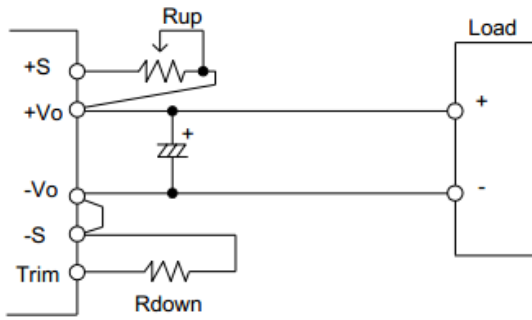The circuit configuration for trim down and trim up is shown in Figure 14.

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Figure 14. Trim Circuit

$$V_f = \frac{1.225 * (\ Rdown\ //\ 32.4)}{7.32 + (\ Rdown\ //\ 32.4)}\quad (V)$$

$$V_{out} = (\ 28 + Rup\ ) * V_f \quad\quad (V)$$

Where

Rdown and Rup are in unit of Kohm
Rdown//32.4 = (Rdown*32.4)/(Rdown+32.4)

When the input voltage is below 40V, the trim-up range is reduced as shown in Figure 15.
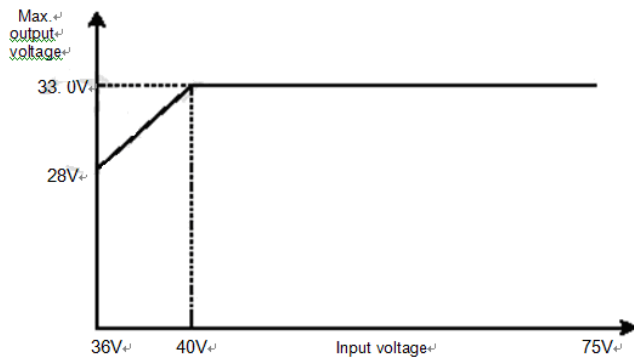

Figure 15. Trim-up Range vs. Input Voltage

Input Under-Voltage Lockout

This feature prevents the converter from starting until the input voltage reaches the turn-on voltage threshold, and keeps the converter running until the input voltage falls below the turn-off voltage threshold. Both turn-on and turn-off voltage thresholds are defined in the Input Specifications table.

Output Over-Current Protection (OCP)

This converter can be ordered in either latch-off or auto-restart version upon OCP.

With the latch-off version, the converter will latch off when the load current exceeds the limit. The converter can be restarted by toggling the ON/OFF switch or recycling the input voltage.

With the auto-restart version, the converter will operate in a hiccup mode (repeatedly try to restart) until the cause of the over-current condition is cleared.

Output Over-Voltage Protection (OVP)

This converter can be ordered in either latch-off or auto-restart version upon OVP.

With the latch-off version, the converter will shut down when the output voltage exceeds the limit. The converter can be restarted by toggling the ON/OFF switch or recycling the input voltage.

With the auto-restart version, the converter will operate in a hiccup mode (repeatedly try to restart) until the cause of the over-voltage condition is cleared.

Over Temperature Protection (OTP)

This converter can be ordered in either latch-off or auto-restart version upon OTP.

With the latch-off version, the converter will shut down and latch off if an over-temperature condition is detected. The converter has a temperature sensor located at a carefully selected position in the converter circuit board, which represents 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 module can be restarted by toggling the ON/OFF switch or recycling the input voltage.

With the auto-restart version, the converter will resume operation after the converter cools down.

Power Good

Power Good (PG) is an open-collector output referenced to Vout(-). It exhibits high impedance when the power module is off and low impedance when the power module is on.

Design Considerations

As with any DC/DC converter, the stability of the FPS4 converters may be compromised if the source impedance is too high or inductive. It's desirable to keep the input source ac-impedance as low as possible. Although the converters are designed to be stable without adding external input capacitors for typical source impedance, it is recommended to add 100 μF low ESR electrolytic capacitors at the input of the converter for each 100W output power, which reduces the potential negative impact of the source impedance on the converter stability. These electrolytic capacitors should have sufficient RMS current rating over the operating temperature range.

The converter is designed to be stable without additional output capacitors. To further reduce the output voltage ripple or improve the transient response, additional output capacitors are often used in applications. When additional output capacitors are used, a combination of ceramic capacitors and tantalum/polymer capacitors shall be used to provide good filtering while assuring the stability of the converter.

Safety Considerations

The FPS4 Series of converters are designed in accordance with EN 62368 Safety of Information Technology Equipment Including Electrical Equipment. The converters are design to meet the requirements in UL 62368, Safety of Information Technology Equipment and applicable Canadian Safety Requirement, and ULc 62368. Flammability ratings of the PWB and plastic components in the converter meet 94V-0.

To protect the converter and the system, an input line fuse is highly recommended on the un-grounded input end.

Thermal Considerations

The FPS4 Series of converters can operate in various thermal environments. Due to the 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 FPS4 Series of converters have been tested comprehensively under various conditions to generate the derating curves with the consideration for long term reliability.

The thermal derating curves are highly influenced by the test conditions. One of the critical variables is the interface method between the converter and the test fixture board. There is no standard method in the industry for the derating tests. Some suppliers use sockets to plug in the converter, while others solder the converter into the fixture board. It should be noticed that these two methods produce significantly different results for a given converter. When the converter is soldered into the fixture board, the thermal performance of the converter is significantly improved compared to using sockets due to the reduction of the contact loss and the thermal impedance from the pins to the fixture board. Other factors affecting the results include the board spacing, construction (especially copper weight, holes and openings) of the fixture board and the spacing board, temperature measurement method and ambient temperature measurement point. The thermal derating curves in this datasheet are obtained using a PWB fixture board and a PWB spacing board with no opening, a board-to-board spacing of 1", and the converter is soldered to the test board with thermal relieves.

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

With single-board DC/DC converter designs, convection heat transfer is the primary cooling means for converters without a baseplate. Therefore, airflow speed should be checked carefully for the intended operating environment. Increasing the airflow over the converter enhances the heat transfer via convection.

Figure 16 shows a recommended temperature monitoring point for open frame modules. For reliable operation, the temperature at this location should not continuously exceed 120 °C.
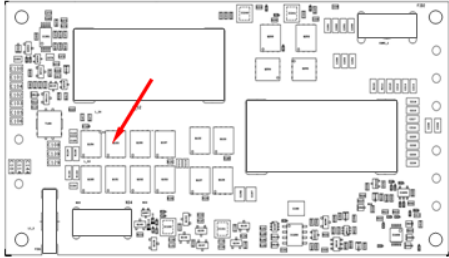

Figure 16. Temperature Monitoring Location

Heat Transfer with a Baseplate

The FPS4 Series of converters have the options of using a baseplate for enhanced thermal performance. The typical height of the converter with the baseplate option is 0.50''. The use of an additional heatsink or cold-plate can further improve the thermal performance of the converter. With the baseplate option, an additional heatsink can be attached to the converter using M3 screws.

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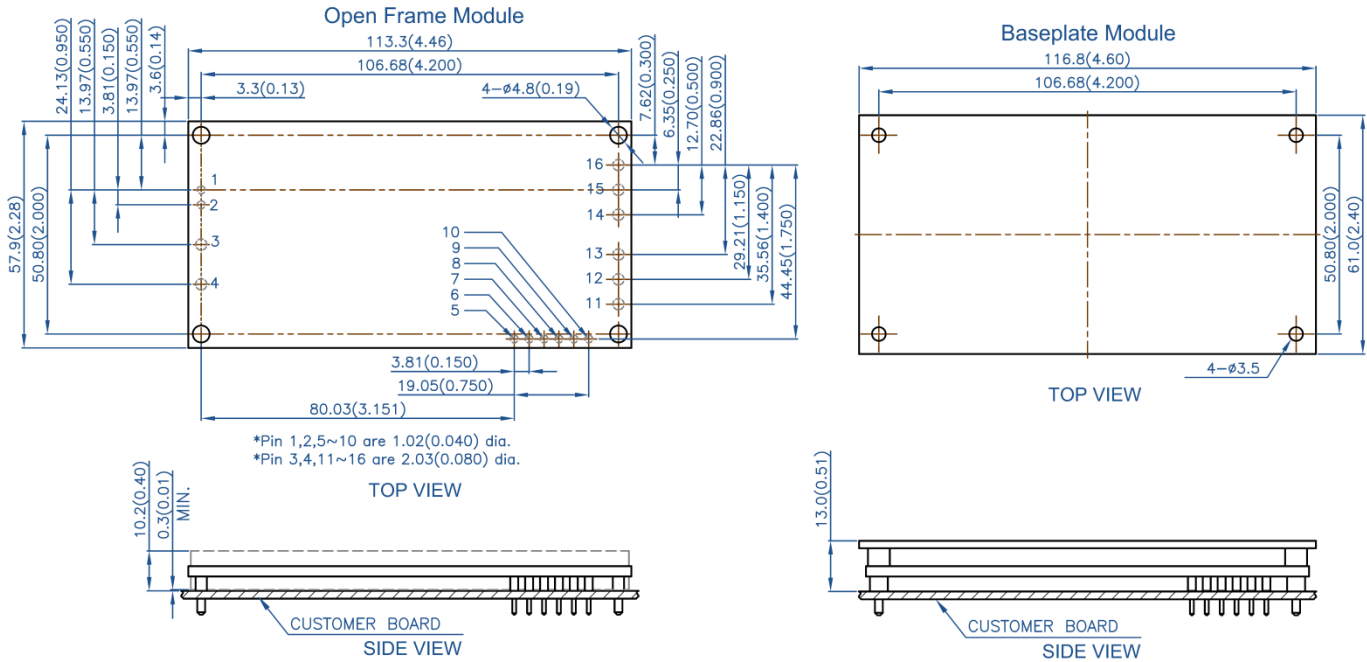
EMC Considerations

The EMC performance of the converter is related to the layout and filtering design of the customer board. Careful layout and adequate filtering around the converter are important to confine noise generated by the switching actions in the converter and to optimize system EMC performance.

Mechanical Drawing

Open Frame Module

Baseplate Module

*Pin 1,2,5~10 are 1.02(0.040) dia.
*Pin 3,4,11~16 are 2.03(0.080) dia.

TOP VIEW

SIDE VIEW

CUSTOMER BOARD

TOP VIEW

SIDE VIEW

CUSTOMER BOARD

Pin	Name	Function	Pin	Name	Function
1	ON/OFF(+)	Remote control	9	SENSE(+)	Positive remote sense
2	ON/OFF(-)	Remote control	10	SENSE(-)	Negative remote sense
3	Vin(+)	Positive input voltage	11	Vout(-)	Negative output voltage
4	Vin(-)	Negative input voltage	12	Vout(-)	Negative output voltage
5	AUX	Auxiliary power supply	13	Vout(-)	Negative output voltage
6	PG	Power good	14	Vout(+)	Positive output voltage
7	NC	No connection	15	Vout(+)	Positive output voltage
8	TRIM	Output voltage adjustment	16	Vout(+)	Positive output voltage

Notes:

1) All dimensions in mm (inches)
   Tolerances: .x $\pm$ .5 (.xx $\pm$ 0.02)
   .xx $\pm$ .25 (.xxx $\pm$ 0.010)
2) Input and control pins are 1.02mm (0.040") dia. with +/- 0.10mm (0.004") tolerance. The recommended diameter of the receiving hole is 1.42mm (0.056'').
3) Output pins are 2.03 mm (0.080") dia. with +/- 0.10mm (0.004") tolerance. The recommended diameter of the receiving hole is 2.44mm (0.096'').
4) All pins are coated with 90%/10% solder, Gold, or Matte Tin finish with Nickel under plating.
5) Weight: 126 g open frame converter
   178 g converter with baseplate
6) Workmanship meets or exceeds IPC-A-610 Class II.
7) Torque applied on screw should not exceed 6in-lb. (0.7 Nm).
8) Baseplate flatness tolerance is 0.10mm (0.004") TIR for surface.