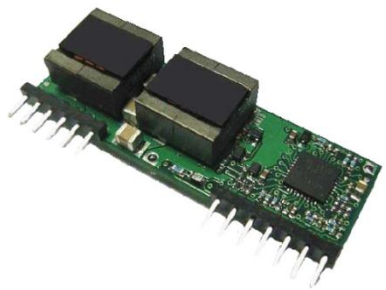
NetPower
Leading the Advancement of Power Conversion

60A NCT Point-of-Load Converter



Features

- High efficiency, 92% (12VInput3.3V/60A)
- Excellent thermal performance
- Over-voltage, over-current, short-circuit, and over temperature protection
- Monotonic start-up into pre-biased load
- UL 60950-1 2nd edition recognized

Options

- Baseplate
- Negative / Positive enable logic
- Frequency synchronization, Sense-, or Power good
- Output voltage tracking/sequence

Part Numbering System

NCT	1	□□□	□	060	□	□	□	□
Series Name:	**Input Voltage:**	**Output Voltage:**	**Enabling Logic:**	**Rated Output Current:**	**Pin Length Options:**	**Electrical Option1:**	**Mechanical Options (ROHS-6 Compliant)**	**Electrical Option2:**
NCT	**1:** 8-16V	**000:** variable (0.8-5V)	**P:** positive **N:** negative	**Unit:** A **060:**60A	**H:** horizontal (0.18'') **R:** vertical (0.13") **T:** vertical (0.17") **S:** SMT	**0:**None **1:**Output tracking	**5:** open frame **6:** baseplate	**0:** None **1:**freq synch. **2:** power good **3:** Sense-

Absolute Maximum Ratings

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	Symbol	Min	Max	Unit
Input Voltage (continuous)	Vi	-0.5	22	Vdc
Operating Ambient Temperature (See Thermal Consideration section)	To	-40	85*	˚C
Storage Temperature	Tstg	-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 operating temperature unless noted otherwise.

Input Specifications

Parameter	Symbol	Min	Typical	Max	Unit
Input Voltage	Vi	8	12	16	Vdc
Input Current	Iin_Max	-	-	40	A
Quiescent Input Current (Typical Vin)	Iin_Qsnt	-	220	280	mA
Standby Input Current	Iin_Stdby	-	22		mA
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 μH source impedance)	-	-	20	-	mAp-p
Input Ripple Rejection (120 Hz)	-		30	-	dB
Input Turn-on Voltage Threshold	-		7.5	8	V

Output Specifications

Parameter		Symbol	Min	Typical	Max	Unit
Output Voltage Set Point Accuracy (Vi = Typical Vin; Io = Io,max; Ta = 25°C)		-	-2.0		+2.0	%
Output Voltage Set Point Accuracy (over all conditions)		-	-2.5		+3.5	%
Output Regulation:						
Line Regulation (full range input voltage, 1/2 full load)		-	-	0.2		%Vo
Load Regulation (full range load, Typical Vin)		-	-	0.3		%Vo
Temperature (Ta = -40°C to 85 °C)		-	-	0.2		%Vo
Output Ripple and Noise Voltage						
RMS		-	-	-	1	%Vo
Peak-to-peak (5 Hz to 20 MHz bandwidth, Typical Vin)				1.5		%Vo
External Load Capacitance		-	-	-	33,000	μF
Output Current		Io	0	-	60	A
Output Current-limit Trip Point (Vo = 90% of Vo,nom)		Io,cli	-	80	-	A
Efficiency (Typical Vin; Io,max, TA = 25ºC)	Vo=0.8V	η		80.5		%
	Vo=1V			83		
	Vo=1.2V			85		
	Vo=1.5V			86.5		
	Vo=1.8V			87.5		
	Vo=2.5V			90		
	Vo=3.3V			92		
	Vo=5V			95		
Output Over Voltage trip point				116		%Vonom
Output Ripple Frequency		-	240	270	300	kHz
PGOOD Source Current					0.1	mA
PGOOD low level voltage			0	0.35	0.4	V
PGOOD high level voltage			4.5	5	5.5	V
PGOOD delay(from Vo reaches regulation point)				5		mS

Output Specifications (continued)

Parameter	Symbol	Min	Typical	Max	Unit
Dynamic Response (Vi = 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 50% to 25% of full load Peak deviation Settling time (within10% band of Vo deviation)			 200 250 200 250		 mV µs mV µs

General Specifications

Parameter	Symbol	Min	Typical	Max	Unit
Remote Enable Positive Logic Logic Low (module OFF) Logic High (module ON) Negative Logic Logic Low: (module ON) Logic High (module OFF)	 $V_{ON/OFF}$ $V_{ON/OFF}$ $V_{ON/OFF}$ $V_{ON/OFF}$	 0 5 0 3.5	 - - - - 	 2.5 16 0.5 16	 V V V V
Calculated MTBF (Telecordia SR-332, 2011, Issue 3), full load, 40°C, 60% upper confidence level, typical Vin			9.8		10^6 -hour

Characteristic Curves

Efficiency (T_{amb}=25°C)

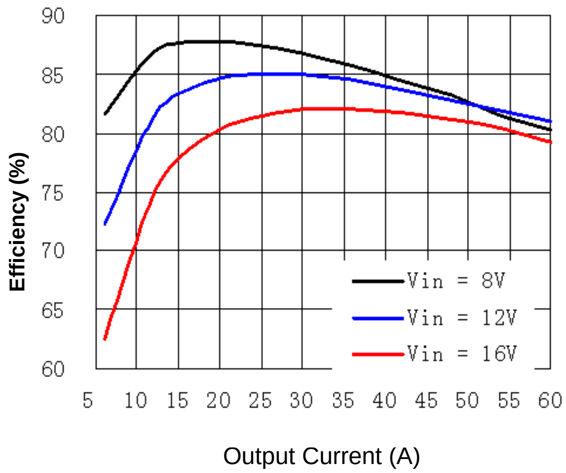


Figure 1(a). Efficiency vs. Load Current (Vout= 0.8V)

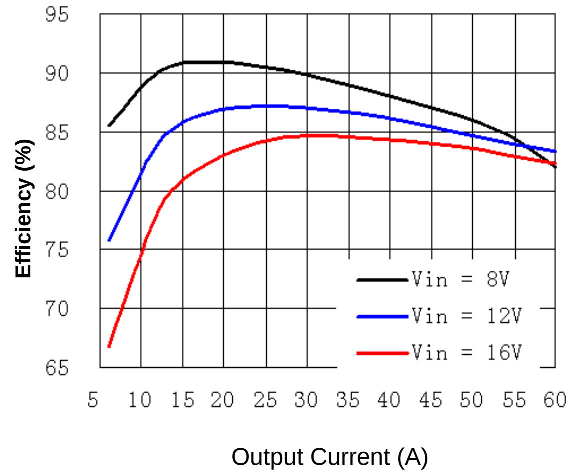


Figure 1(b). Efficiency vs. Load Current (Vout= 1.0V)

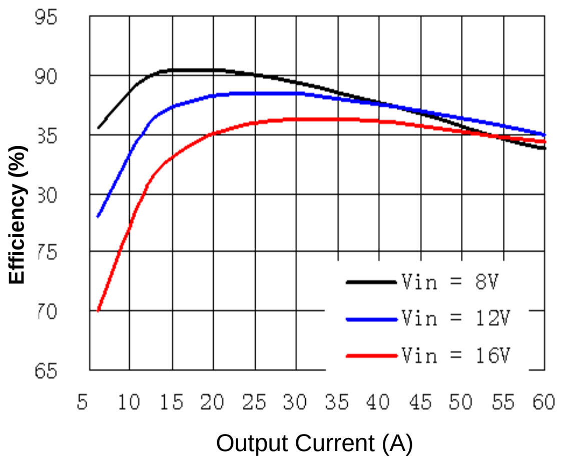


Figure 1(C). Efficiency vs. Load Current (Vout= 1.2V)

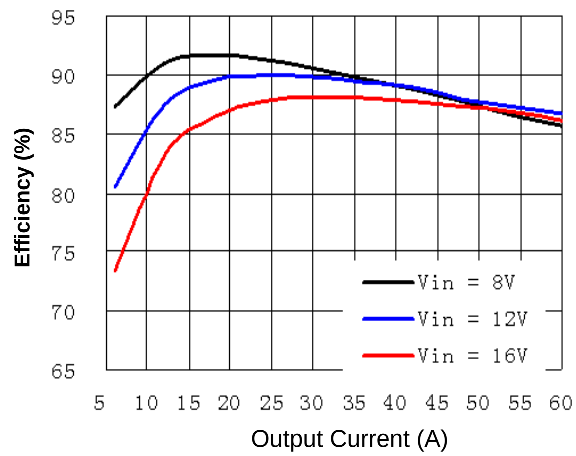


Figure 1(d). Efficiency vs. Load Current (Vout= 1.5V)

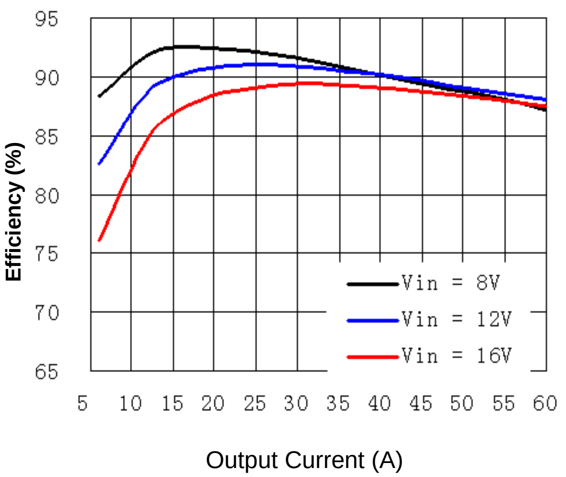


Figure 1(e). Efficiency vs. Load Current (Vout= 1.8V)

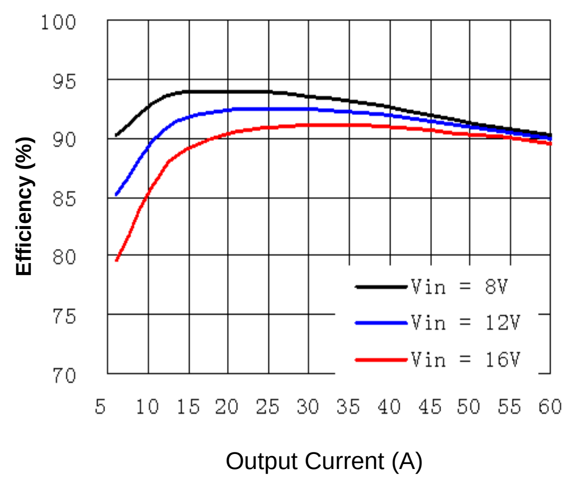


Figure 1(f). Efficiency vs. Load Current (Vout= 2.5V)

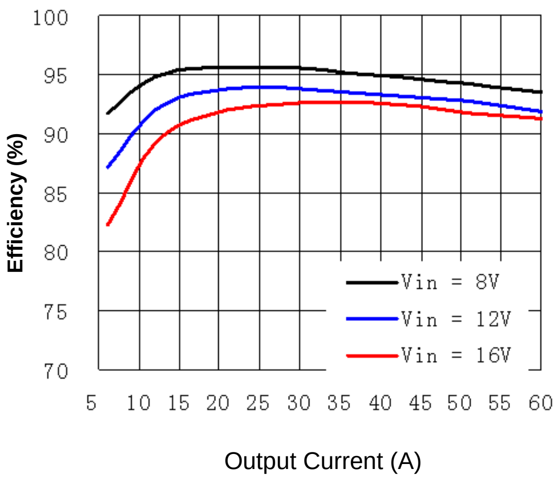


Figure 1(g). Efficiency vs. Load Current (Vout= 3.3V)

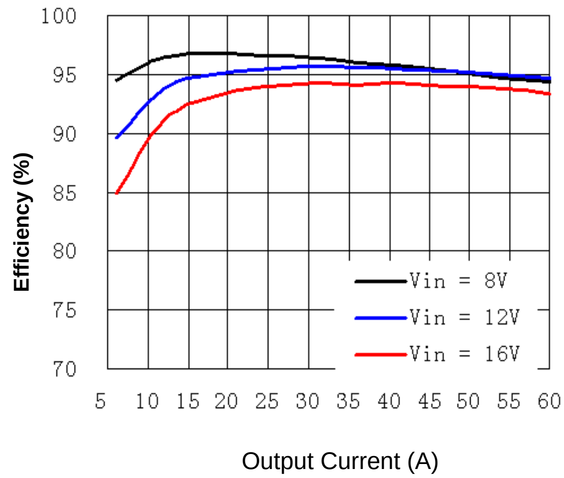


Figure 1(h). Efficiency vs. Load Current (Vout= 5.0V)

Input and Output Characteristics

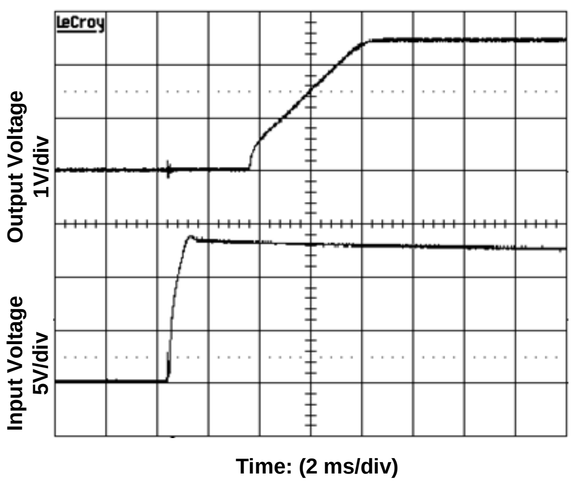


Figure 2. Start-Up from Application of Input Voltage(Input voltage 12V, Output current 0A)

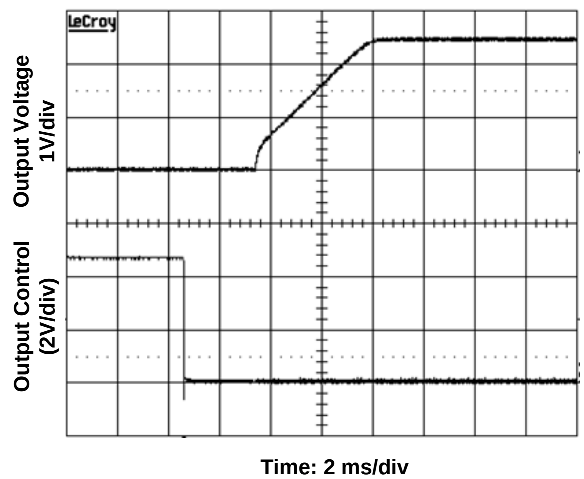


Figure 3. Start-Up from Enable Control (Input voltage 12V, Output current 0A)

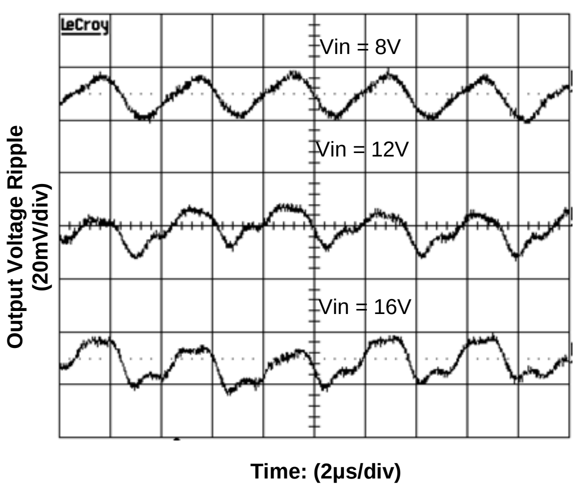


Figure 4. Output Ripple Voltage at 2.5V, 60A Output

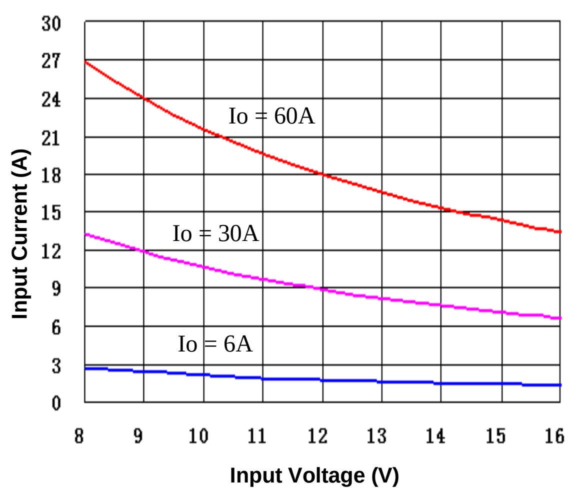


Figure 5. Input Characteristics (3.3V output)

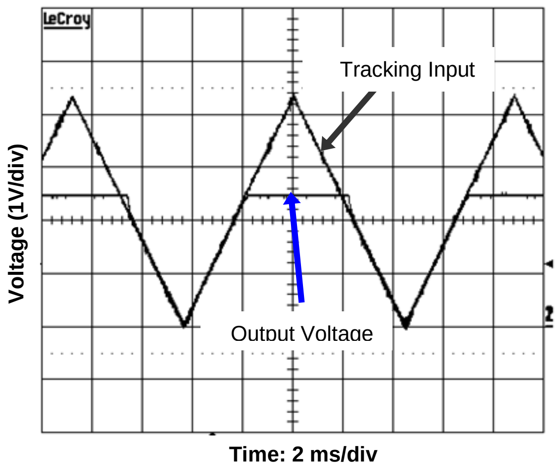


Figure 6. Voltage Tracking/Sequencing (with tracking option)
Vin = 12V, Vo = 2.5V, Io = 0A

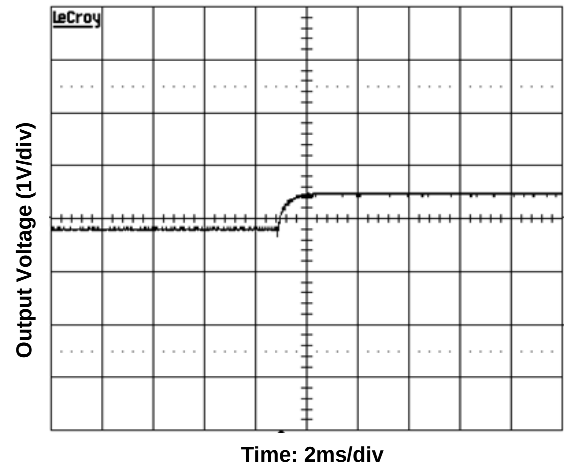


Figure 7. Start-Up with Prebias
Input voltage 12V, Output current 0A, Output voltage 2.5V, Prebias 1.8V

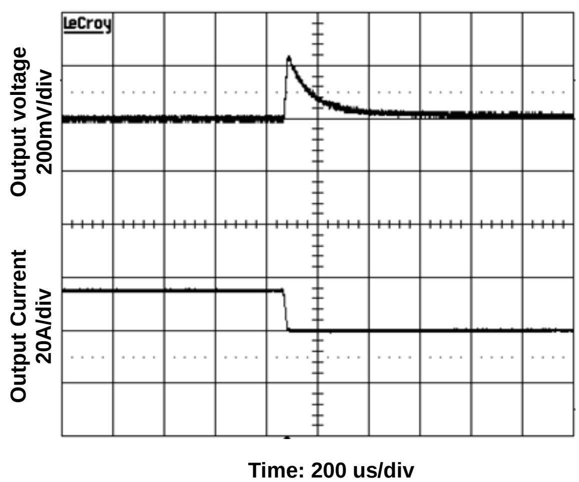


Figure 8. Transient Load Response
Input voltage 12V, Output voltage 2.5V, Output current 45A->30A,. Slew rate 1A/µs.

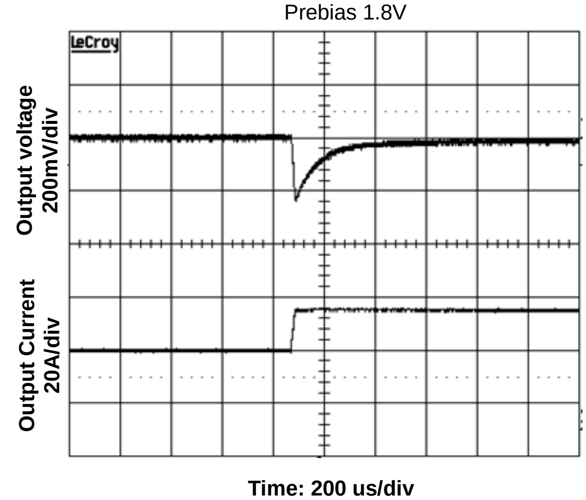


Figure 9. Transient Load Response
Input voltage 12V, Output voltage 2.5V, Output current 30A ->45A, Slew. rate 1A/µs.

Derating Curves (Vin = 12V open frame)

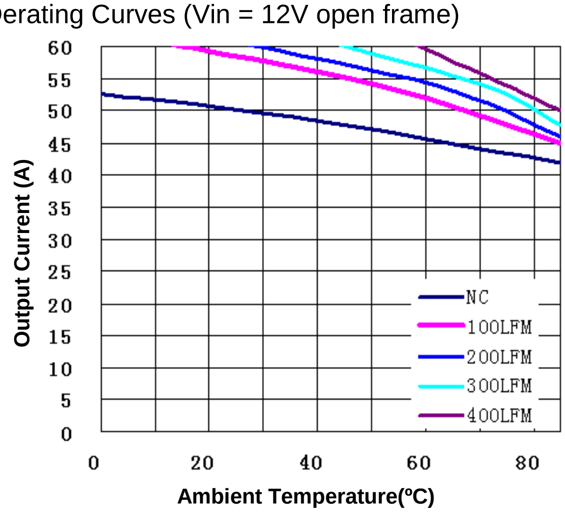


Figure 10(a). Current Derating Curve for0.8V Output

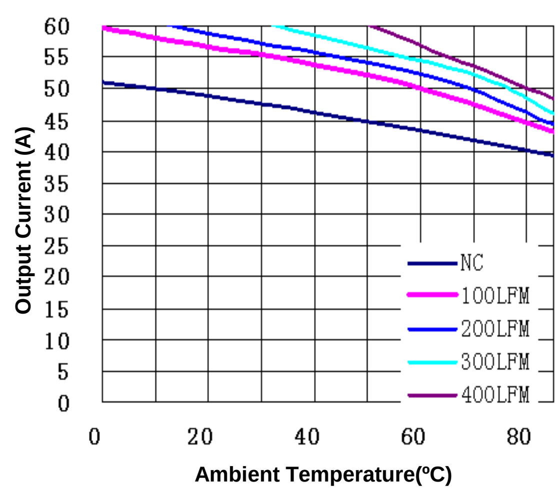


Figure 10(b). Current Derating Curve for 1.0V Output

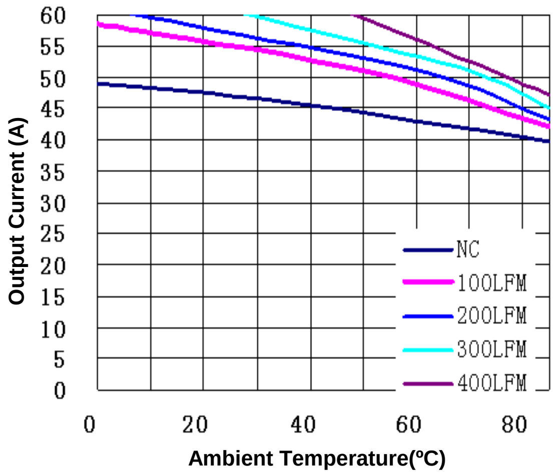


Figure 10(c). Current Derating Curve for 1.2V Output

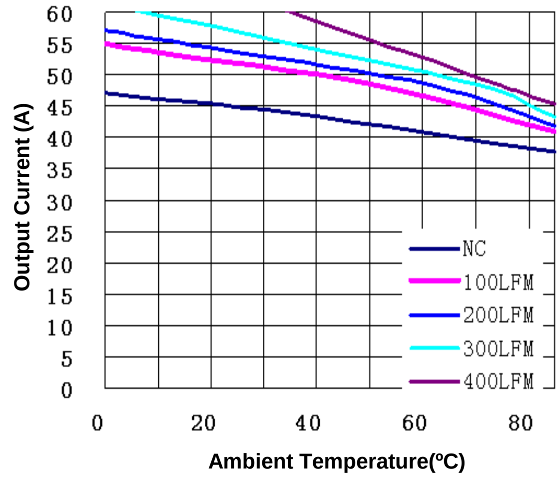


Figure 10(d). Current Derating Curve for 1.5V Output

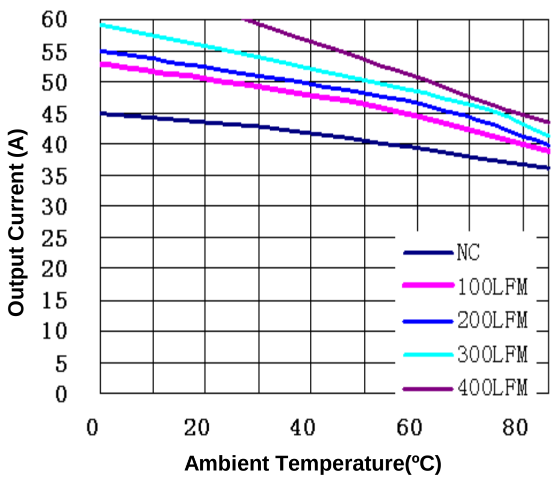


Figure 10(e). Current Derating Curve for 1.8V Output

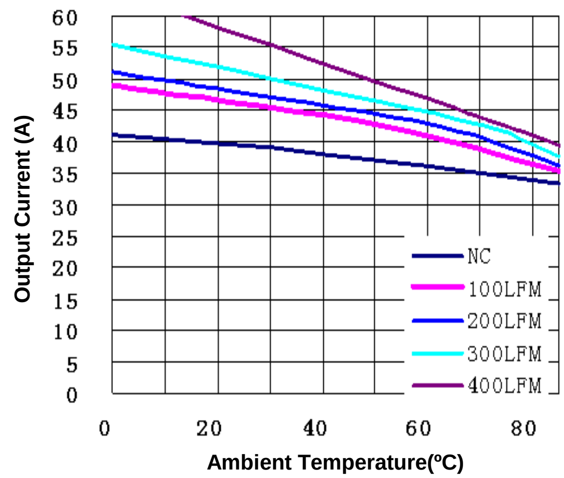


Figure 10(f). CurrentDerating Curve for 2.5V Output

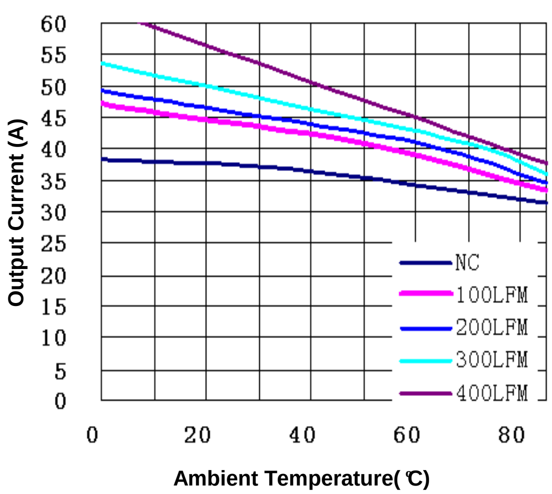


Figure 10(g). Current Derating Curve for 3.3V Output

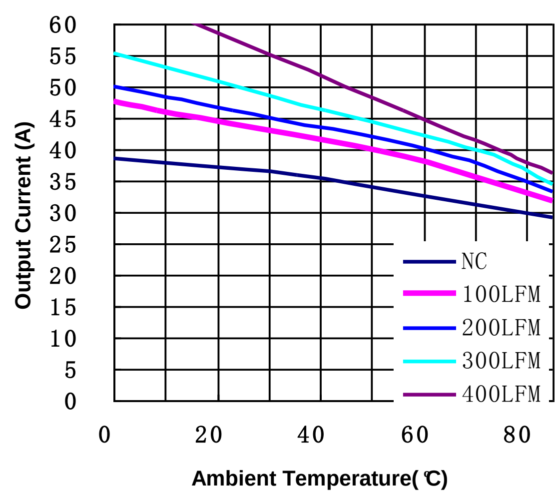


Figure 10(h). Current Derating Curve for 5V Output

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 NCT 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. There is no internal pull-up resistor inside the converter. The converter is ON no matter what control logic is when ON/OFF pin is left open (unconnected).

Figure 11 is the recommended ON/Off control circuit for logic modules, both using open collector/drain circuit. Recommended value of the pull up resistor $R\_{pull\text{-}up}$ is 50K. The maximum allowable leakage current from this pin at logic-high level is 50µA.

Figure 12 shows direct logic control. When this method is used, it's important to make sure that the voltage at the ON/OFF pin is properly set for HIGH and LOW by the direct logic control circuit. For a positive logic enabling NCT module, logic HIGH requires 5.5V or higher voltage at the ON/OFF pin, and logic LOW requires 2.5V or lower voltage at the ON/OFF pin; For a negative logic enabling NCT module, logic HIGH requires 3.5V or higher voltage at the ON/OFF pin, and logic LOW requires 0.5V or lower voltage at the ON/OFF pin.

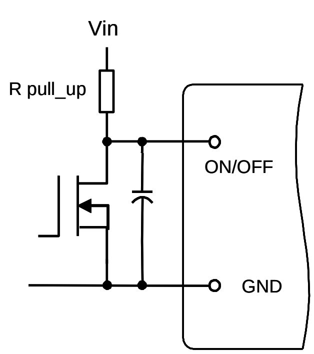


Figure 11. Circuit for Logic Control

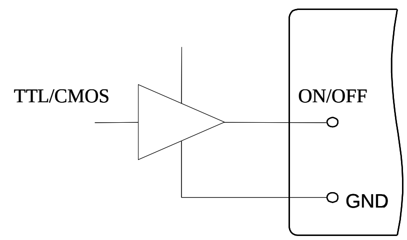


Figure 12. Direct Logic Drive

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 converter has an optional feature Sense- (designated by "3" in Electric Option 2 in the part number). If this option is ordered, Pin 7 is the negative remote sense pin, and should be connected to the location where the ground voltage should be sensed. Without this feature, the voltage drop on the ground (common) connection is not compensated by the converter, and 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 both variable output and fixed output voltages. The variable output voltage model's output voltage is preset to 0.7525V, and can be trimmed up to 5.5V using an external trim resistor. With a trim resistor, the output voltage of fixed output models can only be adjusted higher than the nominal output voltage. To trim the voltage lower than the nominal 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. To increase 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:

$$Rtrim = (\frac{10.5}{\Delta} - 1)(k\Omega)$$

Where

$$\Delta = Vo - Vonom$$

For variable output models,

$$Vonom = 0.7525.$$

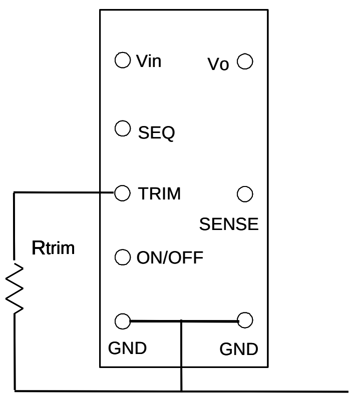


Figure 13. Circuit to Trim Output Voltage.

The circuit configuration for trim operation is shown in Figure13. Because NCT converters use 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 on the output voltage accuracy. If negative remote sense pin option (Sense- selected in Electric Option 2) is selected, the Sense- pin, instead of GND pins, should be connected to Rtrim.

When remote sense and trim functions are used 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 typically 7.5V, with 0.1V hysteresis.

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 persists, 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 and Under Voltage Protection

If the voltage sensed is 16%(typical) lower than the nominal output voltage, the converter will enter under-voltage protection and shut down (in hiccup mode).If the voltage sensed is 16% (typical) higher than the nominal output voltage, the converter will enter over voltage protection and shut down (in hiccup mode). The converter automatically resumes normal operation after the fault condition is removed.

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). 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 not higher than Vin.

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 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 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.

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 to reduce the system noise. The switching frequency of this series of POL converters can be synchronized to an outside clock. The clock frequency ratio is 8, which means the clock frequency should be set at 8 times the desired synchronized switching frequency. It’s desirable to limit the synchronized switching frequency within 10% range of the designed free-running switching frequency. For example, for converters with a nominal switching frequency of 270 kHz, the synchronized switching frequency should be in the range of 243 kHz to 297 kHz, which translates to a clock frequency between 1944 kHz to 2376 kHz.

The key parameters of the clock signal are: pulse duty ratio at 50% typically, logic HIGH level in 3.2–5.5V, logic LOW level less than 0.5V, and being able to source and sink at least 10 uA current. The clock signal should be connected to the optional Pin 7 (“Option” pin). If Frequency Synchronization function is selected, the NCT module will NOT operate when there is NO frequency signal at Pin7.

The effective edge of the synchronization pulse is the falling edge of the clock signal.

Power Good

When POWER GOOD in Electrical Option 2 is selected (referring to the “Part numbering System” table), the option pin (pin 7) will serve as POWER GOOD signal pin to indicate the output status of the module. There is an open collector transistor with 10k pull up resistor connected to this POWER GOOD pin. The voltage for the pull up resistor is 5V internal bias. Before the output voltage of the NCT module reaches its regulation point, the open collector transistor will hold pin 7 to the ground. After the output voltage reaches the regulation point for 5ms, the open collector transistor will become high impedance and pin 7 will be pull to high.

Design Considerations

Input Source Impedance and Filtering

The stability of the NCT 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. Due to the existence of some 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 using a combination of ceramic capacitors and Tantalum/Polymer capacitors at the input, so the relatively higher ESR 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 capacitors usually achieves 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 all of its inputs meet SELV requirements.

Thermal Considerations

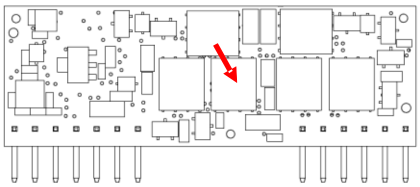


Figure 14. Temperature Monitoring Locations

The NCT converters can operate in various thermal environments. Due to high efficiencies and optimal heat distribution, these converters exhibit excellent thermal performance. Proper cooling in the system can be verified by monitoring the temperature of the key components. Figure 14 shows recommended temperature monitoring point. The temperature at this location should not exceed 125 °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 NCT 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 test conditions and the test setup, such as 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 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.

Heat Transfer without a Baseplate or 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 10 (a) through (h) 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).

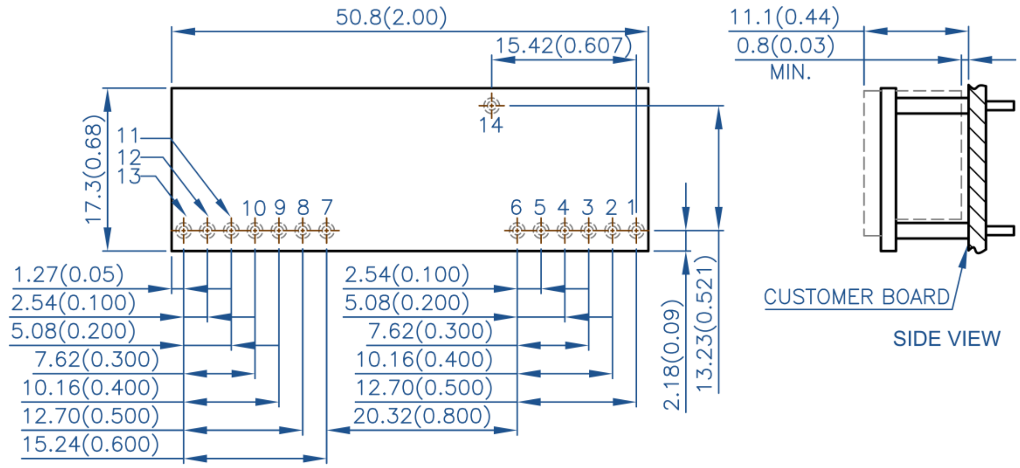
Heat Transfer with a Baseplate

The NCT 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.

Mechanical Diagrams

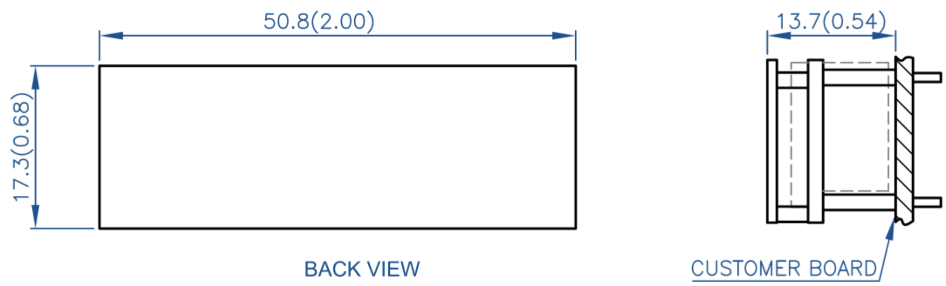
Horizontal Mount

Open Frame Module



*All Pins are 0.94(0.037) dia.
BACK VIEW

Base Plate Module



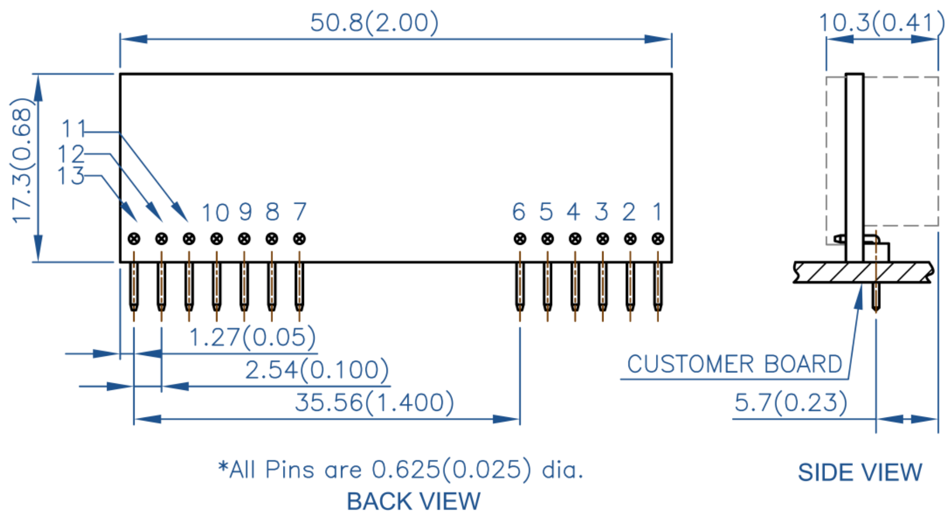
BACK VIEW

SIDE VIEW

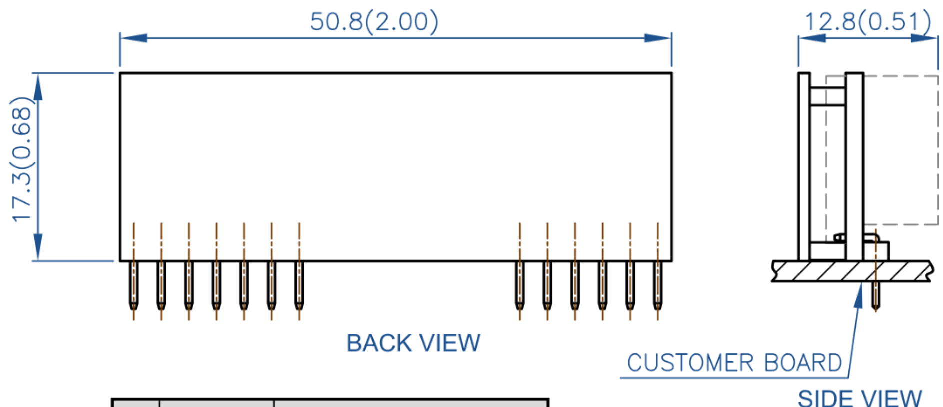
Pin	Name	Function
1	Vout	Output voltage
2	Vout	Output voltage
3	SENSE(+)	Positive remote sense
4	Vout	Output voltage
5	GND	Connected to Vin(-)
6	GND	Connected to Vin(-)
7	OPTION	Freq synch/Power good/Sense-
8	GND	Connected to Vin(-)
9	Vin	Input voltage
10	Vin	Input voltage
11	SEQ	Tracking/Sequencing
12	TRIM	Output voltage adjust
13	ON/OFF	Remote control
14	N/C	No connection

Vertical Mount (SIP)

Open Frame Module



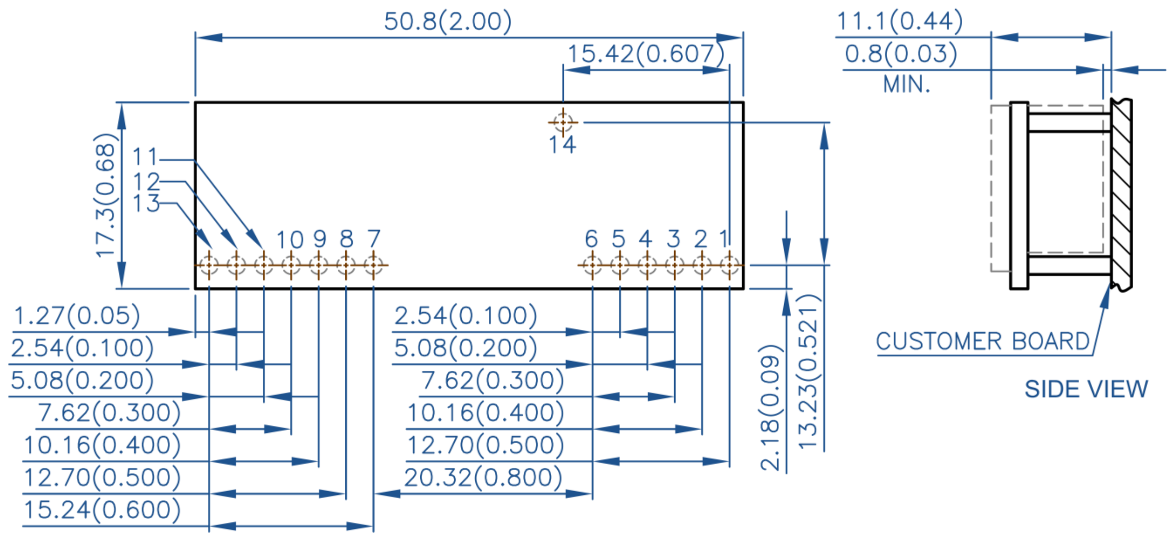
Base Plate Module



Pin	Name	Function
1	Vout	Output voltage
2	Vout	Output voltage
3	SENSE(+)	Positive remote sense
4	Vout	Output voltage
5	GND	Connected to Vin(-)
6	GND	Connected to Vin(-)
7	OPTION	Freq synch/Power good/Sense-
8	GND	Connected to Vin(-)
9	Vin	Input voltage
10	Vin	Input voltage
11	SEQ	Tracking/Sequencing
12	TRIM	Output voltage adjust
13	ON/OFF	Remote control

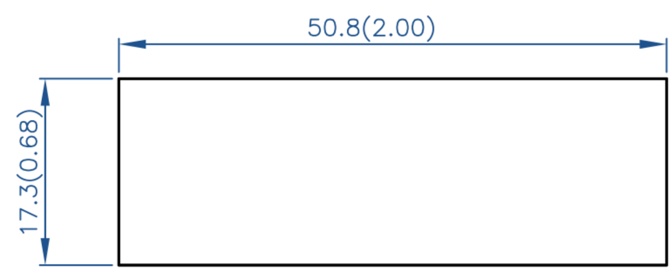
SMT Mount

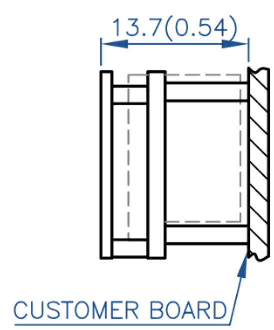
Open Frame Module



*All Pins are 1.65(0.065) dia.
BACK VIEW

Base Plate Module





BACK VIEW

SIDE VIEW

Pin	Name	Function
1	Vout	Output voltage
2	Vout	Output voltage
3	SENSE(+)	Positive remote sense
4	Vout	Output voltage
5	GND	Connected to Vin(-)
6	GND	Connected to Vin(-)
7	OPTION	Freq synch/Power good/Sense-
8	GND	Connected to Vin(-)
9	Vin	Input voltage
10	Vin	Input voltage
11	SEQ	Tracking/Sequencing
12	TRIM	Output voltage adjust
13	ON/OFF	Remote control
14	N/C	No connection

Notes:

1) All dimensions in mm (inches)
   Tolerances: .x $\pm$ .5 (.xx $\pm$ 0.02)
   .xx $\pm$ .25 (.xxx $\pm$ 0.010)
2) SMT pins are also available in horizontal mount version. SMT pins are 0.065'' diameter metal blocks at the same locations as the through-hole pins. Recommended pad diameter is 0.08''
3) A converter's thickness is increased to 0.45'' with a baseplate option.
4) All pins are coated with 90%/10% solder, Gold, or Matte Tin finish with Nickel under plating.
5) Weight: 11.5 g open frame SIP converter
6) Workmanship: Meet or exceeds IPC-A-610 Class II
7) Baseplate flatness tolerance is 0.10mm (0.004") TIR for surface.