0.59-5.5V 12A SMT Point-of Load Converter

Features

- Wide input range: 4.5-14V
- High efficiency: 93.3% (5V/12A)
- DOSA standard footprint and pin-out
- Remote enable control, remote sense
- Output over-current and short-circuit protections
- Output voltage adjustment (trim)
- Power good signal
- Monotonic start-up
- All components meet UL94V-0

Options

- Negative / Positive enable logic
- Output voltage tracking / Sequencing

Part Numbering System

NKS	1	000	□	12	S	□	5
Series Name	**Input Voltage**	**Output Voltage**	**Enabling Logic**	**Output Current**	**Pin Length**	**Electrical Options**	**Other Option**
	1: 4.5-14V	**000:** Variable* (0.59-5.5V)	**P:** Positive **N:** Negative	**Unit:** A **12:** 12A	**S:** SMT	**0:** Default **1:** Voltage Tracking	**5:** RoHS6

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

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)	-0.3	15	Vdc
Sequencing Voltage	-0.3	Vin	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.

Parameter		Min	Typical	Max	Unit
Input Specifications					
Input Voltage		4.5	12	14	Vdc
Input Current		-	-	12	A
Quiescent Input Current (typical Vin, Vo=3.3V)		-	55	-	mA
Standby Input Current		-	1.2	-	mA
Input Reflected-ripple Current, peak-to-peak (5Hz-20MHz, 1µH source impedance)		-	40	-	mA
Output Specifications					
Output Voltage Set Point Accuracy (typical Vin; full load; Ta = 25°C)		-1.5	-	+1.5	%Vo
Output Voltage Set Point Accuracy (over all conditions)		-2.5	-	+2.5	%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)		 - - -	 - - -	 10 10 5	mV
Output Ripple and Noise Voltage RMS Peak-to-peak (5 Hz to 20 MHz bandwidth, typical Vin)		 - -	 20 50	 - -	 mVrms mVp-p
Output Current		0	-	12	A
Efficiency (typical Vin; full load; Ta = 25°C)	Vo=0.59V	-	74.0	-	%
	Vo=1.2V	-	82.5	-	
	Vo=1.8V	-	86.0	-	
	Vo=2.5V	-	88.6	-	
	Vo=3.3V	-	91.0	-	
	Vo=5V	-	93.3	-	
Turn-on Time (full load, Vo within 1% of set point)		-	6	-	ms
Output Over Current Protection Set Point (hiccup mode)		13	-	24	A
Output Ripple Frequency		-	600	-	kHz
External Load Capacitance		-	-	1,200	µF

Voltage Tracking/Sequencing Slew Rate	Power up	-	-	2	V/ms
	Power down	-	-	2	
Dynamic Response (typical Vin; Ta = 25°C; load transient 2.5A/μs) Load steps from 100% to 50% of full load: Peak deviation Settling time (within 10% band of Vo deviation) Load step from 50% to 100% of full load Peak deviation Settling time (within10% band of Vo deviation)		 - - - -	 200 20 200 20	 - - - -	 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 - 3.5 -	 - - - -	 0.6 1.0 5 10	 V μA V mA
Over Temperature Protection		-	140	-	˚C
Power Good Signal (open drain, positive logic)	Output LOW threshold	-	90	-	%Vonom
	Output HIGH threshold	-	110	-	
	Pull down resistance of PGOOD pin	-	7	50	ohm
Calculated MTBF (Telecordia SR-332, 2011, Issue 3), full load, 40°C, 60% upper confidence level, typical Vin		-	14.5	-	10^6 -hour

Characteristic Curves

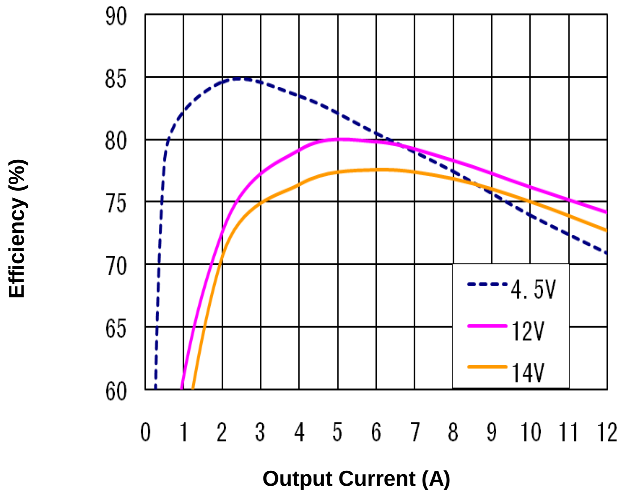


Figure 1a. Efficiency vs. Load Current (25°C, Vo=0.59V)

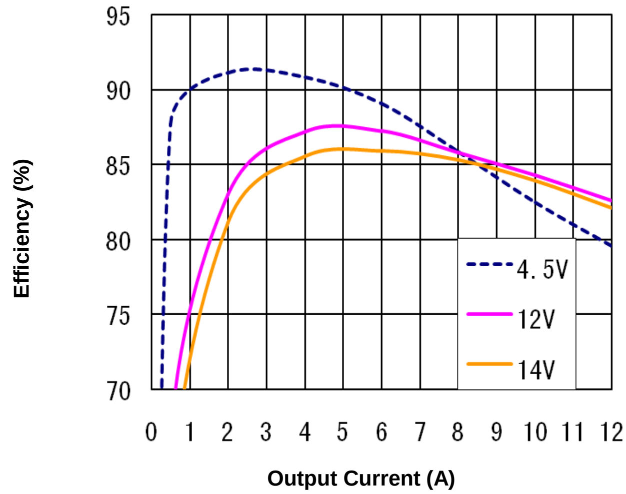


Figure 1b. Efficiency vs. Load Current (25°C, Vo=1.2V)

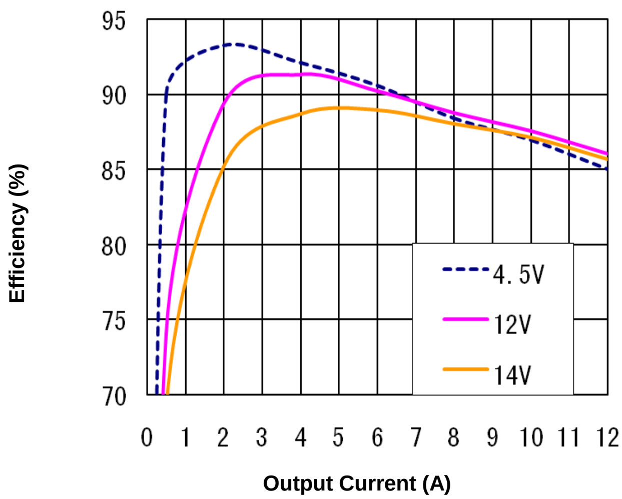


Figure 1c. Efficiency vs. Load Current (25°C, Vo=1.8V)

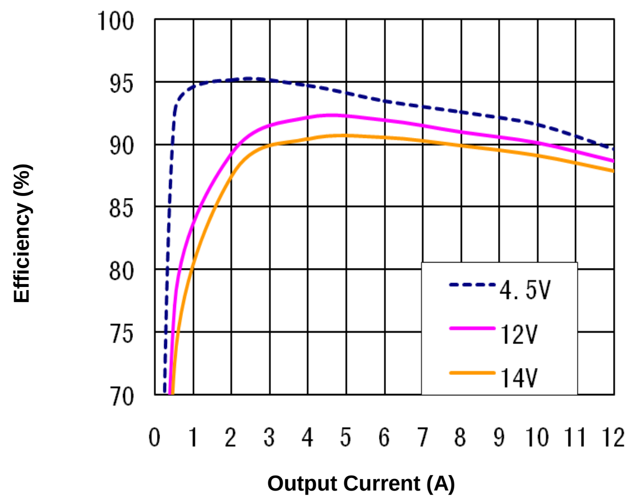


Figure 1d. Efficiency vs. Load Current (25°C, Vo=2.5V)

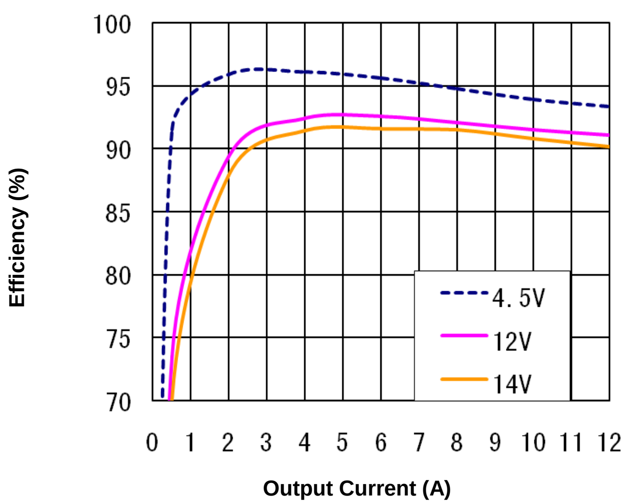


Figure 1f. Efficiency vs. Load Current (25°C, Vo=3.3V)

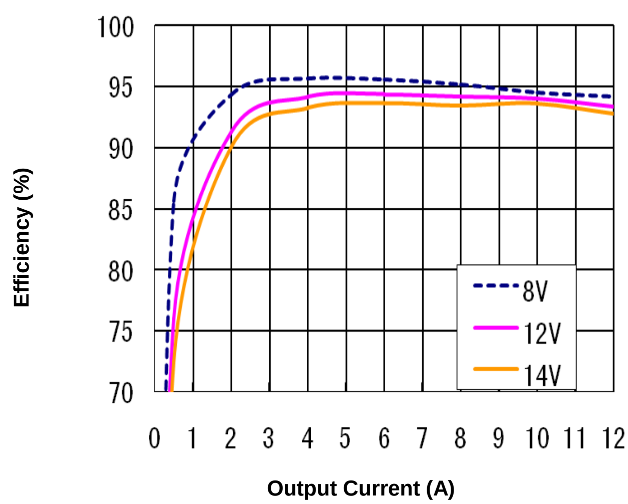
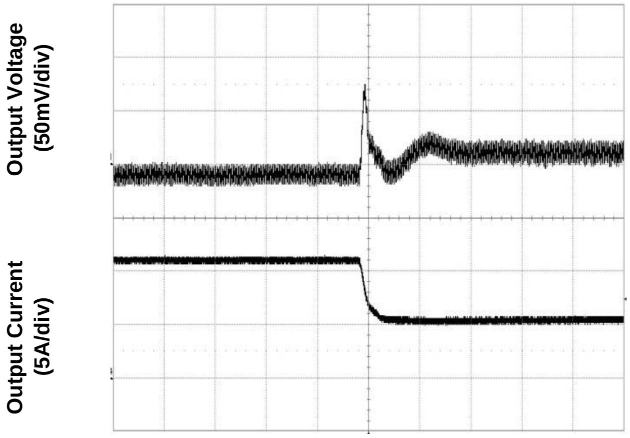
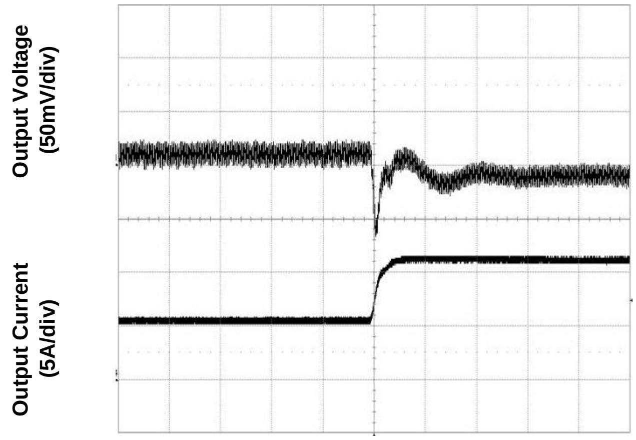


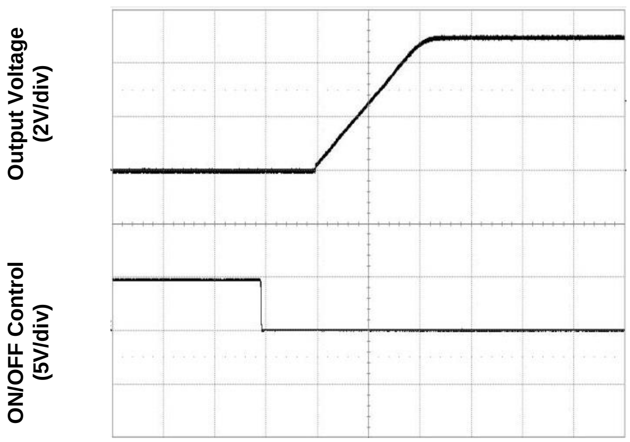
Figure 1g. Efficiency vs. Load Current (25°C, Vo=5V)



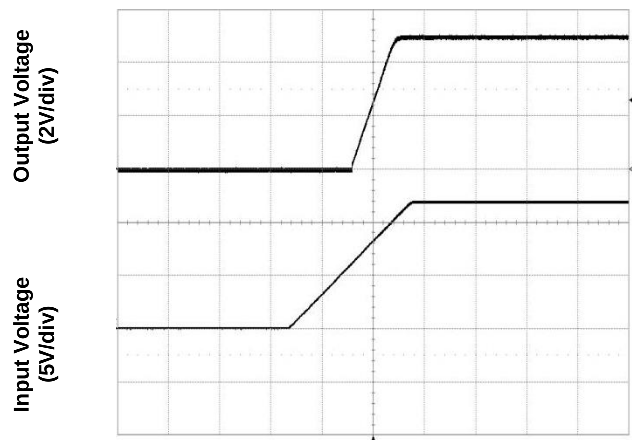
Time – t (50µs/div)
Figure 2. Transient Load Response
(typical Vin, Vo=5V, load current steps from 100% to 50%
at a slew rate 2.5A/µs, Cout-4x220µF)



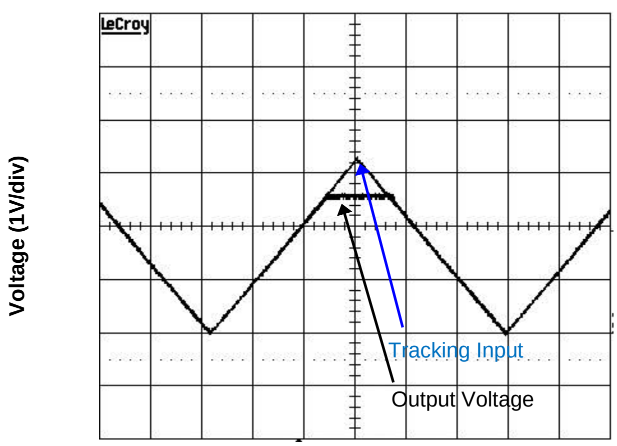
Time – t (50µs/div)
Figure 3. Transient Load Response
(typical Vin, Vo=5V, load current steps from 50% to 100%
at a slew rate 2.5A/µs, Cout-4x220µF)



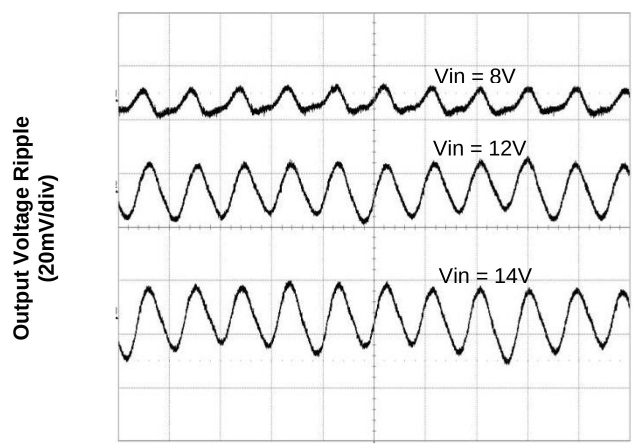
Time – t (2ms/div)
Figure 4. Start-Up from Enable Control
(Vin=12V, 5V/0A output)



Time – t (5ms/div)
Figure 5. Start-Up from Application of Input Voltage
(Vin=12V, 5V/0A output)



Time – t (10ms/div)
Figure 6. Voltage Tracking/Sequencing
(voltage tracking option, Vin=12V, Vo=5V, Io=0A)



Time – t (2µs/div)
Figure 7. Output Ripple Voltage (5V/12A output)

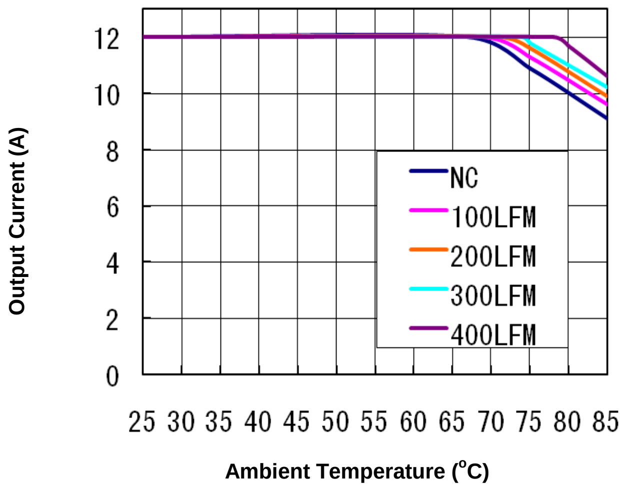


Figure 8a. Current Derating Curve
(Vin=12V, Vo=0.59V, open frame)

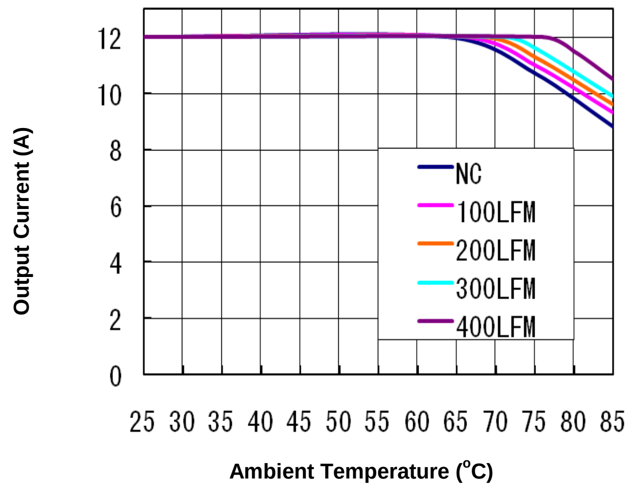


Figure 8b. Current Derating Curve
(Vin=12V, Vo=1.2V, open frame)

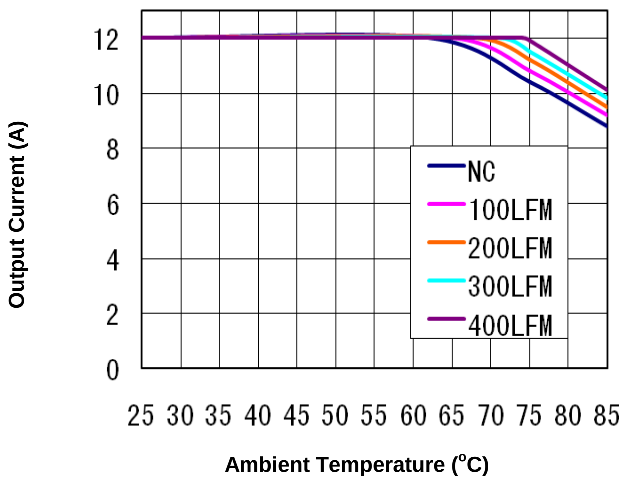


Figure 8c. Current Derating Curve
(Vin=12V, Vo=1.5V, open frame)

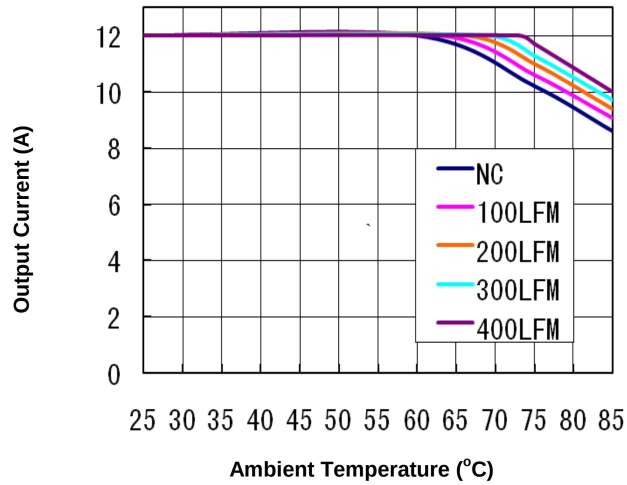


Figure 8d. Current Derating Curve
(Vin=12V, Vo=2.5V, open frame)

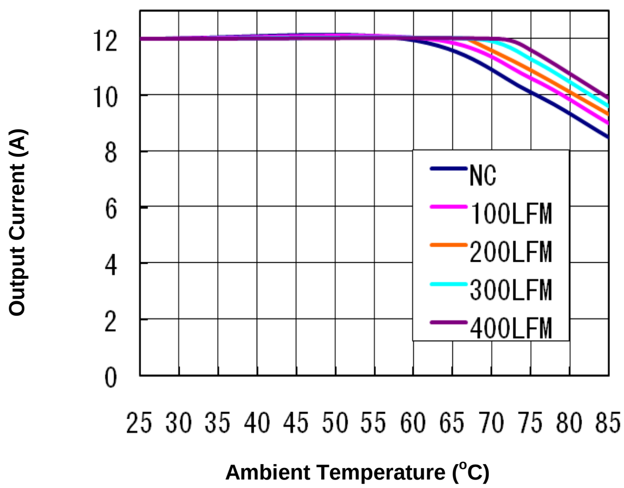


Figure 8e. Current Derating Curve
(Vin=12V, Vo=3.3V, open frame)

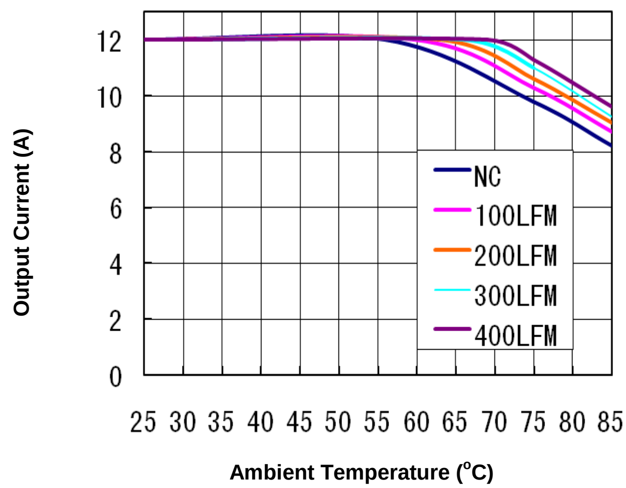


Figure 8f. Current Derating Curve
(Vin=12V, Vo=5V, open frame)

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 NKS 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 9 is the recommended ON/Off control circuit for both positive logic and negative logic modules, recommended value of the pull up resistor R_pull-up is 20Kohm. The maximum allowable leakage current from this pin at logic-high level is listed in the General Specifications table.

The logic low level is from -0.3V to 0.6V and the maximum switch current during logic low is 1μA. The external switch must be capable of maintaining a logic-low level while sinking up to this current.

Figure10 shows direct logic control. When this method is used, it's important to make sure that the voltage at the ON/OFF pin is less than 0.6V in logic LOW state, and is not lower than 3.5V in logic HIGH state.

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.

Since there is no SENSE- pin, the voltage drop on the ground (common) connection is not compensated, and it is important to make sure that the return path resistance is sufficiently low so that the voltage drop across it is acceptable without compensation.

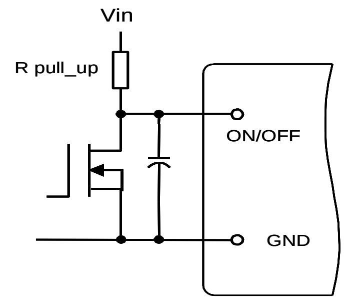


Figure 9. Circuit for Logic Control

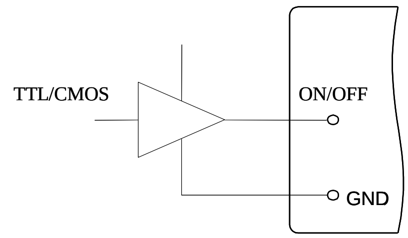


Figure 10. Direct Logic Drive

Output Voltage Programming and Adjustment

This series of converters are available with variable output voltages. The output voltage is preset to 0.59V, and can be programmed up to 5.5V using an external trim resistor. With a trim resistor, the output voltage can only be adjusted higher than the nominal output voltage.

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:

$$Rtrim = \frac{5.91}{Vo - 0.591}(k\Omega)$$

Where

Vo = Desired Output Voltage

Certain restrictions apply on the output voltage set point depending on the input voltage. These are shown in Figure 11. The Upper Limit curve shows that for output voltages below 0.9V, the input voltage must be lower than the maximum of 14V for the converter to operate properly. The Lower Limit curve shows that for output voltages greater than 3.8V, the input voltage needs to be larger than 4.5V.

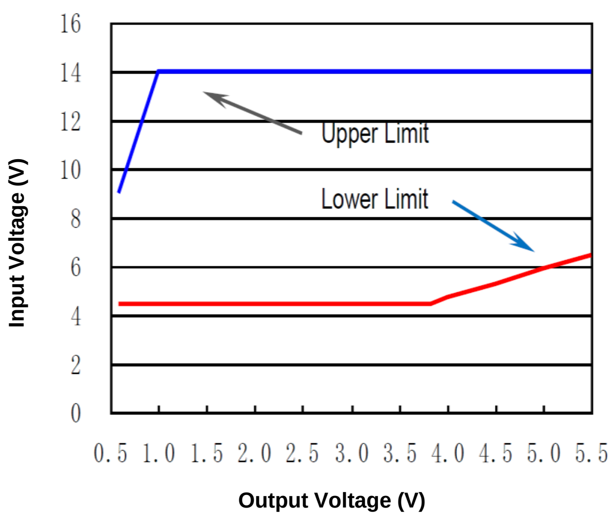


Figure 11. Output Voltage vs. Input Voltage Set Point Area

The circuit configuration for trim operation is shown in Figure 12. Because NKS converters use GND as the reference for control, Rtrim should be placed as close to the GND pin as possible, and the trace connecting the GND pin and Rtrim resistor should not carry significant current, to reduce the effect of voltage drop on the GND trace/plain on the output voltage accuracy.

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

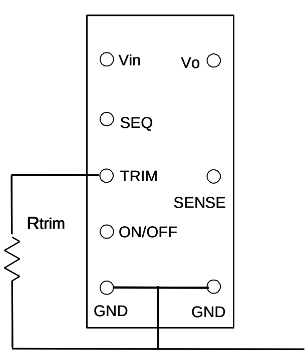


Figure 12. Circuit for Output Voltage Trim

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 thermal shutdown function is designed to turn the converter off when the temperature at the controller reaches 140°C. The converter will resume operation after the converter cools down.

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) and 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 not higher than the input voltage.

This feature 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 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.

Power Good

NKS converters provide a Power Good (PGOOD) signal that is implemented with an open-drain output, in which the high state indicates that the output voltage is within 10% of its set point. The PGOOD signal will be at low state if any of the following conditions exist:

- VFB is more than ±10% from nominal
- soft-start is active
- an under-voltage condition exists
- a short circuit condition has been detected
- die temperature is over 145°C

Design Considerations

The stability of the NKS 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 of the converter. Due to the existence of some inductance (such as the trace inductance, connector inductance, filter inductance, etc) in the input circuitry, possible oscillation may occur at the input of the converter. Because of the relatively high input current of low input voltage power converters, it may not be practical or economical to have separate damping or soft start circuit in front of POL converters. A combination of ceramic capacitors and Tantalum/Polymer capacitors are recommended to be used at the input, so the relatively higher ERS of Tantalum/Polymer capacitors can help to damp the possible oscillation.

Similarly, although the converter is designed to be stable without external capacitor at the output, some low ESR capacitors at the output are desirable to further reduce the output voltage ripple and improve the transient response. A combination of ceramic capacitors and Tantalum/Polymer capacitors at the output usually yields good results.

Thermal Considerations

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

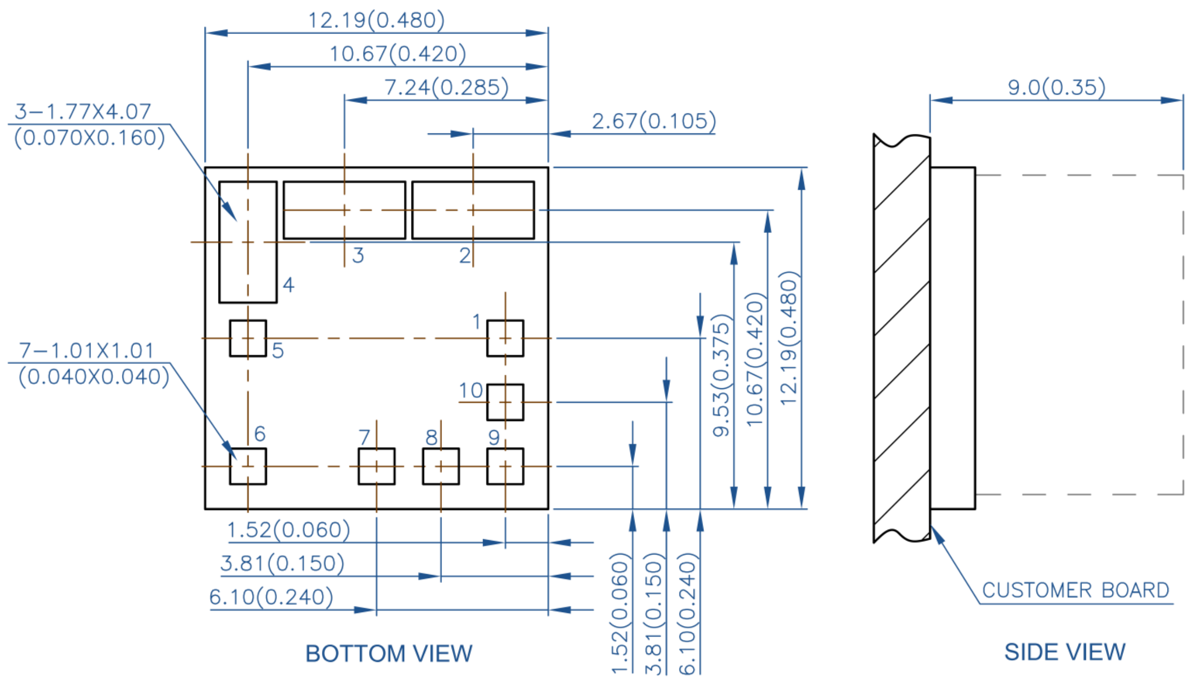
The maximum allowable output power of any power converter is usually determined by the electrical design and the maximum operating temperature of its components. The NKS converters have been tested comprehensively under various conditions to generate the derating curves with consideration for long term 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. The space between the test board and a PWB spacing board is 1".

Convection heat transfer is the primary cooling means for these converters. Therefore, airflow speed is important for any intended operating environment. Increasing the airflow over the converter enhances the heat transfer via convection.

Figures 8(a-f) show the current derating curves under nominal input voltage for a few output voltages. To maintain high 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).

Mechanical Drawing



Pin	Name	Function
1	ON/OFF	Remote control
2	Vin	Input voltage
3	GND	Power ground
4	Vout	Output voltage
5	SENSE	remote sense
6	TRIM	Output voltage adjustment
7	GND	Power ground
8	NC	No connection
9	SEQ	Tracking/Sequencing (optional)
10	PGOOD	Power good

Notes:

1) All dimensions in mm (inches)
   Tolerances: .x ± .5 (.xx ± 0.02)
   .xx ± .25 (.xxx ± 0.010)
2) Weight: 2.5g
3) Workmanship: Meet or exceeds IPC-A-610 Class II.

Recommended Pad Layout