NCP45560

Product Preview

ecoSWITCH™ Advanced Load Management

Controlled Load Switch with Low R_{ON}

The NCP45560 load switch provides a component and area-reducing solution for efficient power domain switching with inrush current limit via soft−start. In addition to integrated control functionality with ultra low on−resistance, this device offers system safeguards and monitoring via fault protection and power good signaling. This cost effective solution is ideal for power management and hot-swap applications requiring low power consumption in a small footprint.

Features

- Advanced Controller with Charge Pump
- Integrated N-Channel MOSFET with Ultra Low R_{ON}
- Soft-Start via Controlled Slew Rate
- Adjustable Slew Rate Control
- Power Good Signal
- Thermal Shutdown
- Undervoltage Lockout
- Short-Circuit Protection
- Input Voltage Range 0.5 V to 13.5 V
- Extremely Low Standby Current
- Load Bleed Function
- This is a Pb−Free Device

Typical Applications

- Portable Electronics and Systems, Notebook and Tablet Computers
- Telecom, Networking, Medical, and Industrial Equipment
- Set−Top Boxes, Servers, and Gateways
- Hot−Swap Devices and Peripheral Ports

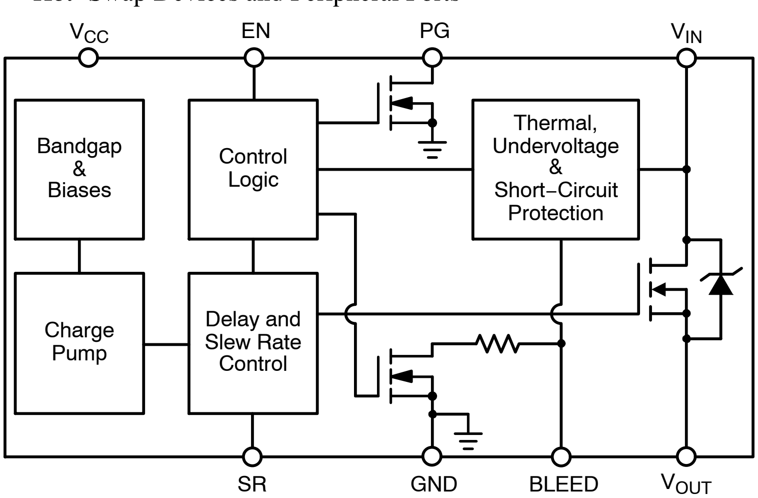

Figure 1. Block Diagram

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.

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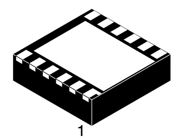
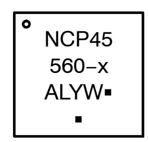
R_{ON} TYP	V_{CC}	V_{IN}	I_{MAX}
2.4 mΩ	3.3 V	1.8 V	23 A
2.6 mΩ	3.3 V	5.0 V	
3.5 mΩ	3.3 V	12 V	



DFN12, 3x3
CASE 506CD

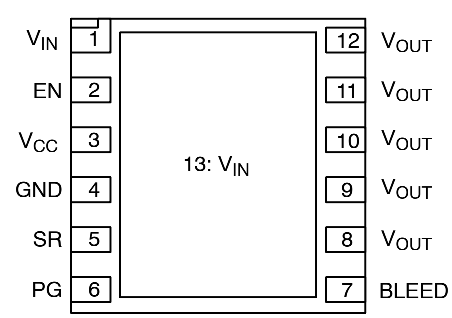
MARKING DIAGRAM



x = H for NCP45560−H
  = L for NCP45560−L
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

(Note: Microdot may be in either location)

PIN CONFIGURATION



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

Table 1. PIN DESCRIPTION

Pin	Name	Function
1, 13	V_{IN}	Drain of MOSFET (0.5 V – 13.5 V), Pin 1 must be connected to Pin 13
2	EN	NCP45560−H − Active−high digital input used to turn on the MOSFET, pin has an internal pull down resistor to GND
		NCP45560−L − Active−low digital input used to turn on the MOSFET, pin has an internal pull up resistor to V_{CC}
3	V_{CC}	Supply voltage to controller (3.0 V − 5.5 V)
4	GND	Controller ground
5	SR	Slew rate adjustment
6	PG	Active−high, open−drain output that indicates when the gate of the MOSFET is fully driven, external pull up resistor ≥ 1 kΩ to an external voltage source required
7	BLEED	Load bleed connection, must be tied to V_{OUT} either directly or through a resistor (see Applications Information)
8−12	V_{OUT}	Source of MOSFET connected to load

Table 2. ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage Range	V_{CC}	−0.3 to 6	V
Input Voltage Range	V_{IN}	−0.3 to 18	V
Output Voltage Range	V_{OUT}	−0.3 to 18	V
EN Digital Input Range	V_{EN}	−0.3 to (V_{CC} + 0.3)	V
PG Output Voltage Range (Note 1)	V_{PG}	−0.3 to 6	V
Thermal Resistance, Junction−to−Ambient, Steady State (Note 2)	$R_{\theta JA}$	28.6	°C/W
Thermal Resistance, Junction−to−Ambient, Steady State (Note 3)	$R_{\theta JA}$	49.7	°C/W
Thermal Resistance, Junction−to−Case (V_{IN} Paddle)	$R_{\theta JC}$	1.7	°C/W
Continuous MOSFET Current @ T_A = 25°C (Notes 2 and 4)	I_{MAX}	23	A
Continuous MOSFET Current @ T_A = 25°C (Notes 3 and 4)	I_{MAX}	17.5	A
Total Power Dissipation @ T_A = 25°C (Note 2) Derate above T_A = 25°C	P_D	3.49 34.9	W mW/°C
Total Power Dissipation @ T_A = 25°C (Note 3) Derate above T_A = 25°C	P_D	2.01 20.1	W mW/°C
Storage Temperature Range	T_{STG}	−40 to 150	°C
Lead Temperature, Soldering (10 sec.)	T_{SLD}	260	°C
ESD Capability, Human Body Model (Notes 5 and 6)	ESD_{HBM}	2.0	kV
ESD Capability, Machine Model (Notes 5)	ESD_{MM}	200	V
ESD Capability, Charged Device Model (Note 5)	ESD_{CDM}	1.0	kV
Latch−up Current Immunity (Note 5)	LU	100	mA

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. PG is an open−drain output that requires an external pull up resistor ≥ 1 kΩ to an external voltage source.
2. Surface−mounted on FR4 board using 1 sq−in pad, 1 oz Cu.
3. Surface−mounted on FR4 board using the minimum recommended pad size, 1 oz Cu.
4. Ensure that the expected operating MOSFET current will not cause the Short−Circuit Protection to turn the MOSFET off undesirably.
5. Tested by the following methods @ T_A = 25°C:
   ESD Human Body Model tested per JESD22−A114
   ESD Machine Model tested per JESD22−A115
   ESD Charged Device Model per ESD STM5.3.1
   Latch−up Current tested per JESD78
6. Rating is for all pins except for V_{IN} and V_{OUT} which are tied to the internal MOSFET's Drain and Source. Typical MOSFET ESD performance for V_{IN} and V_{OUT} should be expected and these devices should be treated as ESD sensitive.

Table 3. OPERATING RANGES

Rating	Symbol	Min	Max	Unit
Supply Voltage	V_{CC}	3	5.5	V
Input Voltage	V_{IN}	0.5	13.5	V
Ground	GND		0	V
Ambient Temperature	T_A	−40	85	°C
Junction Temperature	T_J	−40	125	°C

Table 4. ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise specified)

Parameter	Conditions (Note 7)	Symbol	Min	Typ	Max	Unit
MOSFET						
On−Resistance	V_{CC} = 3.3 V; V_{IN} = 1.8 V	R_{ON}		2.4	TBD	mΩ
	V_{CC} = 3.3 V; V_{IN} = 5 V			2.6	TBD	
	V_{CC} = 3.3 V; V_{IN} = 12 V			3.5	TBD	
Leakage Current (Note 8)	V_{EN} = 0 V; V_{IN} = 13.5 V	I_{LEAK}		0.1	1.0	μA
CONTROLLER						
Supply Standby Current (Note 9)	V_{EN} = 0 V; V_{CC} = 3 V	I_{STBY}		0.65	2.0	μA
	V_{EN} = 0 V; V_{CC} = 5.5 V			3.2	4.5	
Supply Dynamic Current (Note 10)	V_{EN} = V_{CC} = 3 V; V_{IN} = 12 V	I_{DYN}		280	400	μA
	V_{EN} = V_{CC} = 5.5 V; V_{IN} = 1.8 V			530	750	
Bleed Resistance	V_{EN} = 0 V; V_{CC} = 3 V	R_{BLEED}	86	115	144	Ω
	V_{EN} = 0 V; V_{CC} = 5.5 V		72	97	121	
Bleed Pin Leakage Current	V_{EN} = V_{CC} = 3 V, V_{IN} = 1.8 V	I_{BLEED}		6.0	10	μA
	V_{EN} = V_{CC} = 3 V, V_{IN} = 12 V			60	70	
EN Input High Voltage	V_{CC} = 3 V – 5.5 V	V_{IH}	2.0			V
EN Input Low Voltage	V_{CC} = 3 V – 5.5 V	V_{IL}			0.8	V
EN Input Leakage Current	NCP45560−H; V_{EN} = 0 V	I_{IL}		90	500	nA
	NCP45560−L; V_{EN} = V_{CC}	I_{IH}		90	500	
EN Pull Down Resistance	NCP45560−H	R_{PD}	76	100	124	kΩ
EN Pull Up Resistance	NCP45560−L	R_{PU}	76	100	124	kΩ
PG Output Low Voltage (Note 11)	V_{CC} = 3 V; I_{SINK} = 5 mA	V_{OL}			0.2	V
PG Output Leakage Current (Note 12)	V_{CC} = 3 V; V_{TERM} = 3.3 V	I_{OH}		5.0	100	nA
Slew Rate Control Constant (Note 13)	V_{CC} = 3 V	K_{SR}	24	31	38	μA
FAULT PROTECTIONS						
Thermal Shutdown Threshold (Note 14)	V_{CC} = 3 V – 5.5 V	T_{SDT}		145		°C
Thermal Shutdown Hysteresis (Note 14)	V_{CC} = 3 V – 5.5 V	T_{HYS}		20		°C
V_{IN} Undervoltage Lockout Threshold	V_{CC} = 3 V	V_{UVLO}	0.25	0.35	0.45	V
V_{IN} Undervoltage Lockout Hysteresis	V_{CC} = 3 V	V_{HYS}	20	50	70	mV
Short−Circuit Protection Threshold	V_{CC} = 3 V; V_{IN} = 0.5 V	V_{SC}	200	265	350	mV
	V_{CC} = 3 V; V_{IN} = 13.5 V		100	285	500	

7. V_{EN} shown only for NCP45560−H, (EN Active−High) unless otherwise specified.
8. Average current from V_{IN} to V_{OUT} with MOSFET turned off.
9. Average current from V_{CC} to GND with MOSFET turned off.
10. Average current from V_{CC} to GND after charge up time of MOSFET.
11. PG is an open-drain output that is pulled low when the MOSFET is disabled.
12. PG is an open-drain output that is not driven when the gate of the MOSFET is fully charged, requires an external pull up resistor ≥ 1 kΩ to an external voltage source, V_{TERM}.
13. See Applications Information section for details on how to adjust the slew rate.
14. Operation above T_J = 125°C is not guaranteed.

Table 5. SWITCHING CHARACTERISTICS (T_J = 25°C unless otherwise specified) (Notes 15 and 16)

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Output Slew Rate	V_{CC} = 3.3 V; V_{IN} = 1.8 V	SR		11.9		kV/s
	V_{CC} = 5.0 V; V_{IN} = 1.8 V			12.0		
	V_{CC} = 3.3 V; V_{IN} = 12 V			13.0		
	V_{CC} = 5.0 V; V_{IN} = 12 V			13.4		
Output Turn−on Delay	V_{CC} = 3.3 V; V_{IN} = 1.8 V	T_{ON}		215		μs
	V_{CC} = 5.0 V; V_{IN} = 1.8 V			190		
	V_{CC} = 3.3 V; V_{IN} = 12 V			295		
	V_{CC} = 5.0 V; V_{IN} = 12 V			280		
Output Turn−off Delay	V_{CC} = 3.3 V; V_{IN} = 1.8 V	T_{OFF}		3.9		μs
	V_{CC} = 5.0 V; V_{IN} = 1.8 V			3.2		
	V_{CC} = 3.3 V; V_{IN} = 12 V			1.2		
	V_{CC} = 5.0 V; V_{IN} = 12 V			0.7		
Power Good Turn−on Time	V_{CC} = 3.3 V; V_{IN} = 1.8 V	$T_{PG,ON}$		1.55		ms
	V_{CC} = 5.0 V; V_{IN} = 1.8 V			1.03		
	V_{CC} = 3.3 V; V_{IN} = 12 V			1.96		
	V_{CC} = 5.0 V; V_{IN} = 12 V			1.34		
Power Good Turn−off Time	V_{CC} = 3.3 V; V_{IN} = 1.8 V	$T_{PG,OFF}$		19		ns
	V_{CC} = 5.0 V; V_{IN} = 1.8 V			13		
	V_{CC} = 3.3 V; V_{IN} = 12 V			19		
	V_{CC} = 5.0 V; V_{IN} = 12 V			13		

15. See below figure for Test Circuit and Timing Diagram.
16. Tested with the following conditions: $V_{TERM} = V_{CC}$; R_{PG} = 100 kΩ; R_L = 10 Ω; C_L = 0.1 μF.

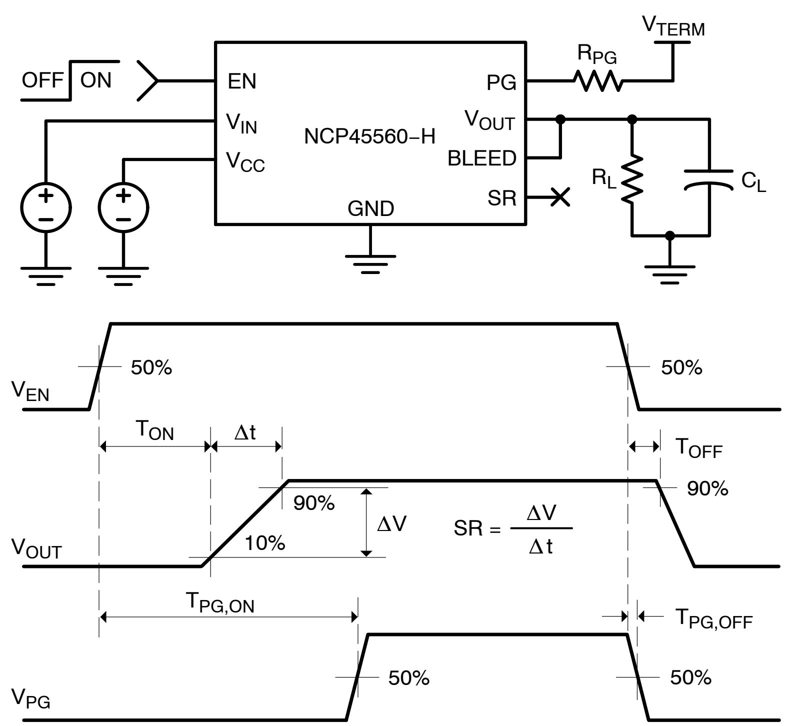


Figure 2. Switching Characteristics Test Circuit and Timing Diagrams

APPLICATIONS INFORMATION

Enable Control

The NCP45560 has two part numbers, NCP45560-H and NCP45560-L, that only differ in the polarity of the enable control.

The NCP45560-H part allows for enabling the MOSFET in an active-high configuration. When the EN pin is at a logic high level and the V_{CC} supply pin has an adequate voltage applied, the MOSFET will be enabled. Similarly, when the EN pin is at a logic low level, the MOSFET will be disabled. An internal pull down resistor to ground on the EN pin ensures that the MOSFET will be disabled when not being driven.

The NCP45560-L part allows for enabling the MOSFET in an active-low configuration. When the EN pin is at a logic low level and the V_{CC} supply pin has an adequate voltage applied, the MOSFET will be enabled. Similarly, when the EN pin is at a logic high level, the MOSFET will be disabled. An internal pull up resistor to V_{CC} on the EN pin ensures that the MOSFET will be disabled when not being driven.

Load Bleed

The NCP45560 device has an on-chip bleed resistor that is used to bleed the charge off of the load to ground after the MOSFET has been disabled. In series with the bleed resistor is a bleed switch that is enabled whenever the MOSFET is disabled. Delays are added to the enable of this switch to ensure that both the MOSFET and the bleed switch are not concurrently active.

In order to realize this functionality and for the short-circuit protection to operate correctly, the BLEED pin must be connected to V_{OUT} either directly or through a resistor, R_{EXT}, which should not exceed 1 kΩ.

Power Good

The NCP45560 device has a power good output (PG) that is used to indicate when the gate of the MOSFET is fully driven. The PG pin is an active-high, open-drain output that requires an external pull up resistor ≥ 1 kΩ to an external voltage source compatible with input levels of other devices connected to this pin. When the power good feature is not used in the application, the PG pin can be tied to ground.

Short−Circuit Protection

The NCP45560 device is equipped with short-circuit protection that is used to help protect the part and the system from a sudden high-current event, such as the output, V_{OUT}, being shorted to ground. This circuitry is only active when the gate of the MOSFET is fully driven.

Once active, the circuitry monitors the difference in the voltage on the V_{IN} pin and the voltage on the BLEED pin. When the difference is equal to the short-circuit protection threshold voltage, the MOSFET is immediately turned off and the load bleed is activated. The part remains latched in this off state until EN is toggled or V_{CC} supply voltage is cycled, at which point the MOSFET will be turned on in a controlled fashion with the normal output turn-on delay and slew rate.

In order for the V_{OUT} voltage to be monitored through the BLEED pin, it is required that the BLEED pin be connected to V_{OUT} either directly or through a resistor, R_{EXT}, which should not exceed 1 kΩ.

Thermal Shutdown

The thermal shutdown of the NCP45560 device protects the part from internally or externally generated excessive temperatures. This circuitry is disabled when EN is not active to reduce standby current. When an over-temperature condition is detected, the MOSFET is immediately turned off and the load bleed is activated.

The part comes out of thermal shutdown when the junction temperature decreases to a safe operating temperature as dictated by the thermal hysteresis. Upon exiting a thermal shutdown state, and if EN remains active, the MOSFET will be turned on in a controlled fashion with the normal output turn-on delay and slew rate.

Undervoltage Lockout

The undervoltage lockout of the NCP45560 device turns the MOSFET off and activates the load bleed when the input voltage, V_{IN}, drops below the undervoltage lockout threshold. This circuitry is disabled when EN is not active to reduce standby current.

If the V_{IN} voltage rises above the undervoltage lockout threshold, and EN remains active, the MOSFET will be turned on in a controlled fashion with the normal output turn-on delay and slew rate.

Slew Rate Control

The NCP45560 device is equipped with controlled output slew rate which provides soft−start functionality. This limits the inrush current caused by capacitor charging and enables these devices to be used in hot swapping applications.

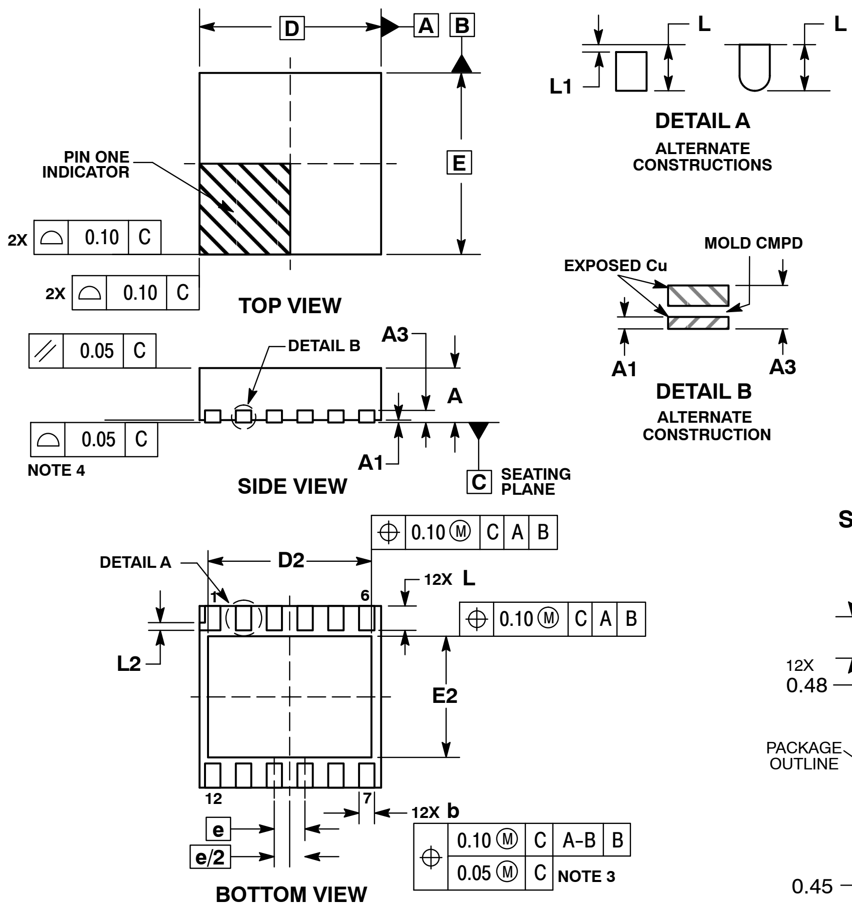
The slew rate can be decreased with an external capacitor added between the SR pin and ground. With an external capacitor present, the slew rate can be determined by the following equation:

$$\text{Slew Rate} = \frac{K_{SR}}{C_{SR}}\ [\text{V/s}] \qquad \text{(eq. 1)}$$

where K_{SR} is the specified slew rate control constant, found in Table 4, and C_{SR} is the slew rate control capacitor added between the SR pin and ground. Note that the slew rate of the device will always be the lower of the default slew rate and the adjusted slew rate. Therefore, if the C_{SR} is not large enough to decrease the slew rate more than the specified default value, the slew rate of the device will be the default value.

PACKAGE DIMENSIONS

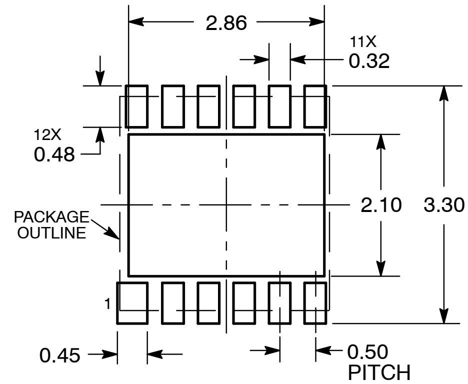
DFN12 3x3, 0.5P
CASE 506CD
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

	MILLIMETERS	
DIM	MIN	MAX
A	0.80	1.00
A1	0.00	0.05
A3	0.20 REF	
b	0.20	0.30
D	3.00 BSC	
D2	2.60	2.80
E	3.00 BSC	
E2	1.90	2.10
e	0.50 BSC	
L	0.20	0.40
L1	---	0.15
L2	0.10 REF	

RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

ORDERING INFORMATION

Device	EN Polarity	Package	Shipping†
NCP45560IMNTWG−H	Active−High	DFN12 (Pb−Free)	3000 / Tape & Reel
NCP45560IMNTWG−L	Active−Low		

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
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