NCP4545

ecoSwitch™
Advanced Load Management
Controlled Load Switch with Low R_{ON}

The NCP4545 load switch provides a component and area-reducing solution for efficient power domain switching with inrush current limit via soft start. It is designed to integrate control and driver functionality with a high performance low on-resistance power MOSFET in a single device. 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
- Soft−Start via Adjustable Slew Rate Control
- Low On−Resistance
- Input Voltage Range 0.5 V to 6 V
- Low Standby Current
- Load Bleed Function
- No External Components Required
- Enable Pin with CMOS Input Levels
- This is a Pb−Free Device

Typical Applications

- Notebook and Tablet Computers
- Handheld Electronics
- Digital Cameras
- Portable Medical Devices
- Hard Drives
- Peripheral Ports

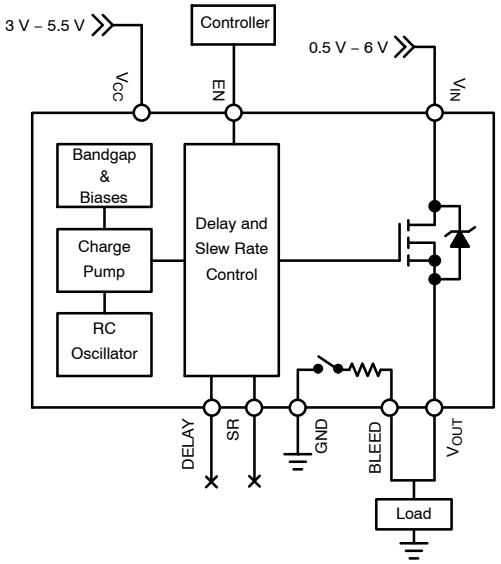


Figure 1. Typical Application − No external components included

ON Semiconductor®

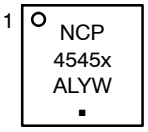
http://onsemi.com

R_{ON} TYP	V_{CC}	V_{IN}	I_{MAX}
4.7 mΩ	5.0 V	1.8 V	10.5 A
5.9 mΩ	3.3 V	5.0 V	



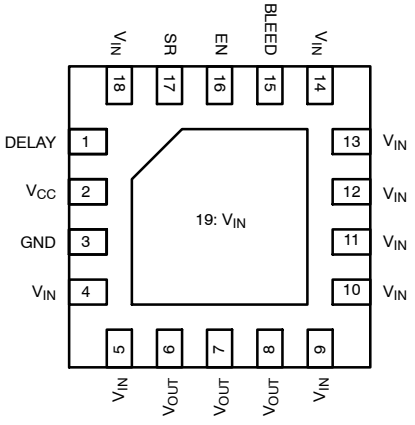
QFN18, 3x3
CASE 485BF

MARKING DIAGRAM



x	= Blank for EN Active−High = L for EN Active−Low
A	= Assembly Location
L	= Wafer Lot
Y	= Year
W	= Work Week
▪	= Pb−Free Package

PIN CONFIGURATION



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information on page 4 of this data sheet.

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PIN DESCRIPTION

Pin	Name	Function
1	DELAY	Turn−on delay adjustment
2	V_{CC}	Supply voltage to controller (3.0 V − 5.5 V)
3	GND	Controller ground
4, 5, 9−14, 18, 19	V_{IN}	Drain of MOSFET (0.5 V − 6.0 V)
6−8	V_{OUT}	Source of MOSFET connected to load
15	BLEED	Load bleed connection
16	EN	NCP4545IMNTWG − Active−High digital input used to turn on the MOSFET, pin has an internal pull down resistor to GND
		NCP4545IMNTWG−L − Active−Low digital input used to turn on the MOSFET, pin has an internal pull up resistor to V_{CC}
17	SR	Slew rate adjustment

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 6	V
Output Voltage Range	V_{OUT}	−0.3 to 6	V
EN Digital Input Range	V_{EN}	−0.3 to (V_{CC} + 0.3)	V
Thermal Resistance, Junction−to−Air (Note 1)	$R_{\theta JA}$	49.9	°C/W
Thermal Resistance, Junction−to−Air (Note 2)	$R_{\theta JA}$	32.8	°C/W
Thermal Resistance, Junction−to−Case (V_{IN} Paddle)	$R_{\theta JC}$	3.3	°C/W
Continuous MOSFET Current (Note 3)	I_{MAX}	10.5	A
Total Power Dissipation @ T_A = 25°C (Notes 1 and 4) Derate above T_A = 25°C	P_D	1.30 20.1	W mW/°C
Total Power Dissipation @ T_A = 25°C (Notes 2 and 4) Derate above T_A = 25°C	P_D	1.98 30.5	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}	4.0	kV
ESD Capability, Machine Model (Note 5)	ESD_{MM}	200	V
ESD Capability, Charged Device Model (Note 5)	ESD_{CDM}	1	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. Surface−mounted on FR4 board using the minimum recommended pad size, 1 oz Cu.
2. Surface−mounted on FR4 board using 1 sq−in pad, 1 oz Cu.
3. Current limited by package.
4. Specified for derating purposes only, ensure that I_{MAX} is never exceeded.
5. Tested by the following methods @ T_A = 25°C:
   ESD Human Body Model tested per AEC−Q100−002 (EIA/JESD22−A114)
   ESD Machine Model tested per EIA/JESD22−A115
   ESD Charged Device Model per EIA/JESD22−C101
   Latch−up Current Maximum Rating: ≤100 mA per JEDEC standard: 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.

OPERATING RANGES

Rating	Symbol	Min	Max	Unit
Supply Voltage	V_{CC}	3	5.5	V
Input Voltage	V_{IN}	0.5	6	V
Ground	GND		0	V
Ambient Temperature	T_A	0	70	°C
Junction Temperature	T_J	0	90	°C

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

Parameter	Conditions (Note 7)	Symbol	Min	Typ	Max	Unit
MOSFET						
On−Resistance	V_{CC} = 5.0 V; V_{IN} = 1.8 V	R_{ON}		4.7	5.9	mΩ
	V_{CC} = 5.0 V; V_{IN} = 5.0 V			4.9	6.1	
	V_{CC} = 3.3 V; V_{IN} = 1.8 V			5.0	6.7	
	V_{CC} = 3.3 V; V_{IN} = 5.0 V			5.9	7.0	
Leakage Current (Note 8)	V_{EN} = 0 V; V_{IN} = 6 V	I_{LEAK}		0.025	1.0	μA
CONTROLLER						
Supply Standby Current (Note 9)	V_{EN} = 0V; V_{CC} = 5.5 V	I_{STBY}		5.0	15	μA
Supply Dynamic Current (Note 10)	V_{EN} = V_{CC} = 5.5 V	I_{DYN}		250	500	μA
Bleed Resistance		R_{BLEED}	50	100	200	Ω
EN Input High Voltage		V_{IH}	2.0			V
EN Input Low Voltage		V_{IL}			0.8	V
EN Pull Down Resistance	NCP4545IMNTWG	R_{PD}	40	100	180	kΩ
EN Pull Up Resistance	NCP4545IMNTWG−L	R_{PU}	40	100	180	kΩ

7. V_{EN} shown only for NCP4545IMNTWG (EN Active−High).
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.

SWITCHING CHARACTERISTICS (T_J = 25°C unless otherwise specified, Note 11)

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
V_{CC} = 5.0 V, V_{IN} = 1.8 V						
Output Slew Rate (Note 12)	R_L = 10 Ω, C_L = 0.1 μF	SR		8.4		kV/s
Output Turn−on Delay (Note 12)	R_L = 10 Ω, C_L = 0.1 μF	T_{ON}		525		μs
Output Turn−off Delay	R_L = 10 Ω, C_L = 0.1 μF	T_{OFF}		2.0		μs
V_{CC} = 3.3 V, V_{IN} = 5.0 V						
Output Slew Rate (Note 12)	R_L = 10 Ω, C_L = 0.1 μF	SR		3.7		kV/s
Output Turn−on Delay (Note 12)	R_L = 10 Ω, C_L = 0.1 μF	T_{ON}		930		μs
Output Turn−off Delay	R_L = 10 Ω, C_L = 0.1 μF	T_{OFF}		1.1		μs

11. See below figure for Test Circuit and Timing Diagrams.
12. See Applications Information below for details on how to adjust this parameter.

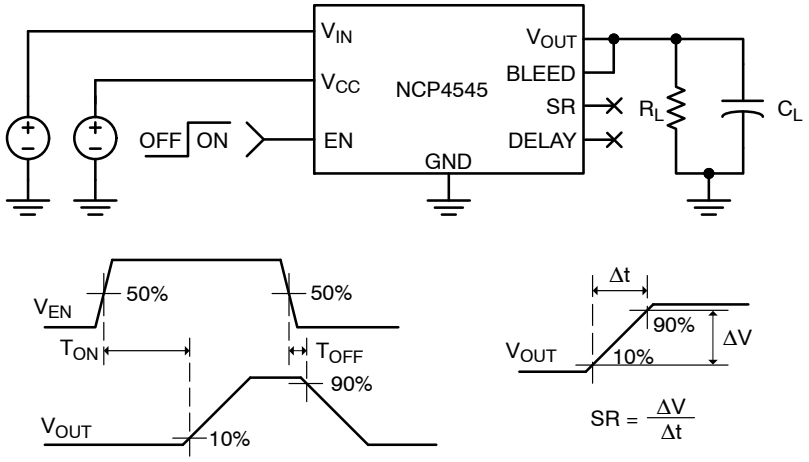


Figure 2. Test Circuit and Timing Diagrams

ORDERING INFORMATION

Device	EN Polarity	Package	Shipping†
NCP4545IMNTWG	Active−HIGH	QFN18 (Pb−Free)	3000 / Tape & Reel
NCP4545IMNTWG−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.

TYPICAL CHARACTERISTICS

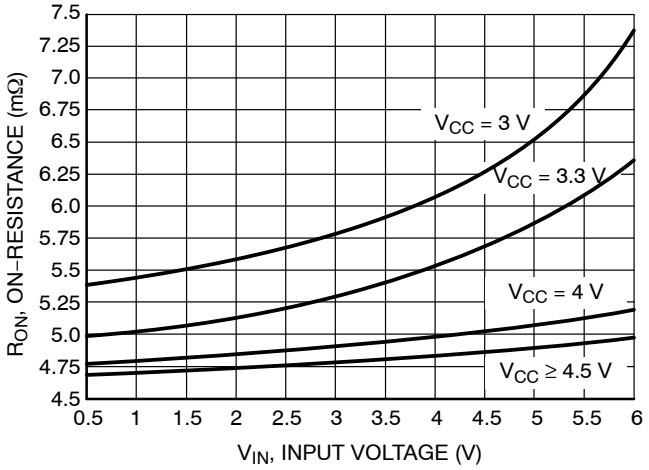


Figure 3. On−Resistance vs. Input Voltage

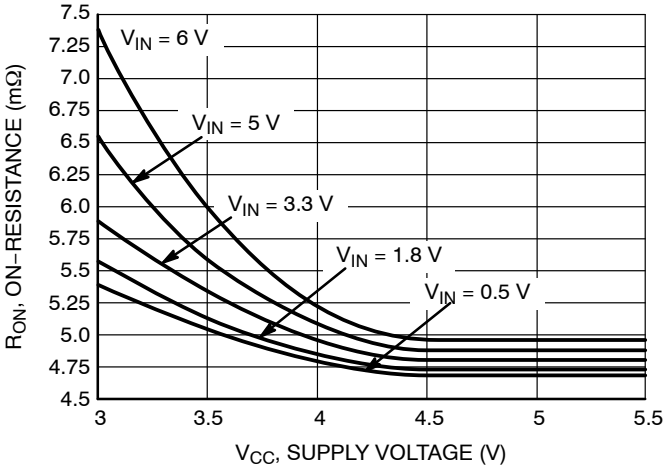


Figure 4. On−Resistance vs. Supply Voltage

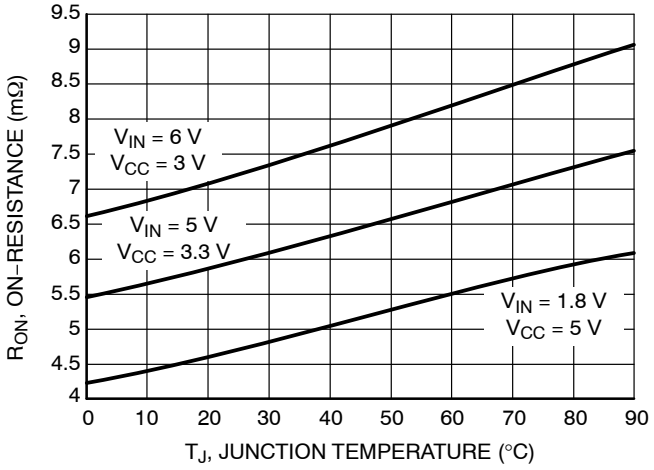


Figure 5. On−Resistance vs. Temperature

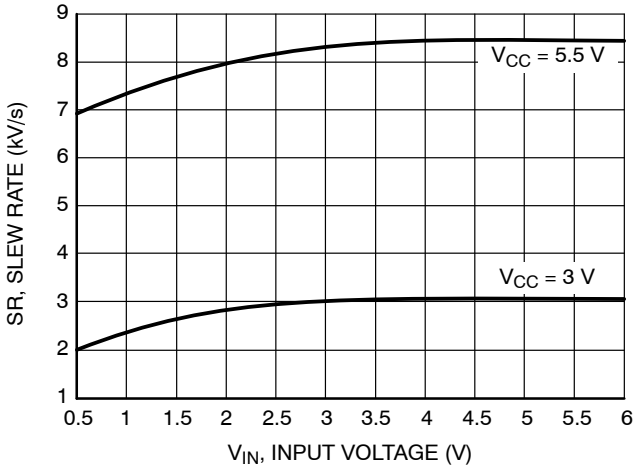


Figure 6. Slew Rate vs. Input Voltage

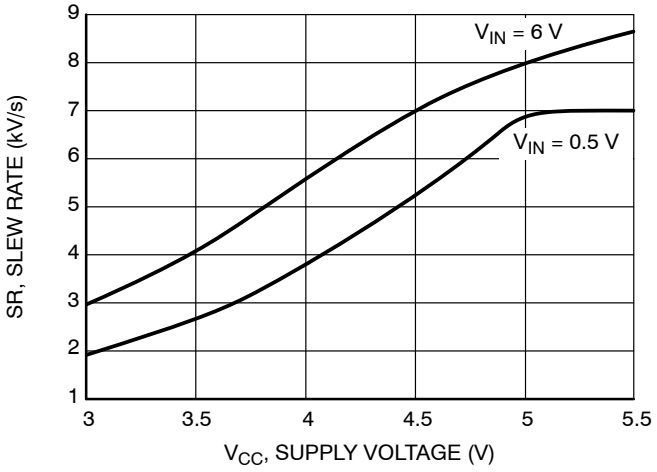


Figure 7. Slew Rate vs. Supply Voltage

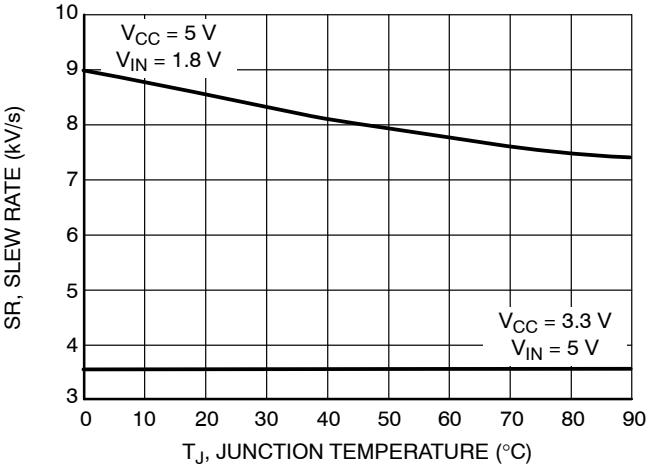


Figure 8. Slew Rate vs. Temperature

TYPICAL CHARACTERISTICS

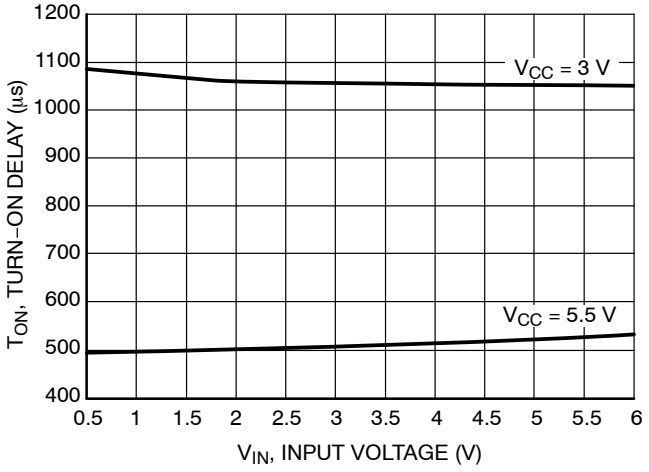


Figure 9. Turn−On Delay vs. Input Voltage

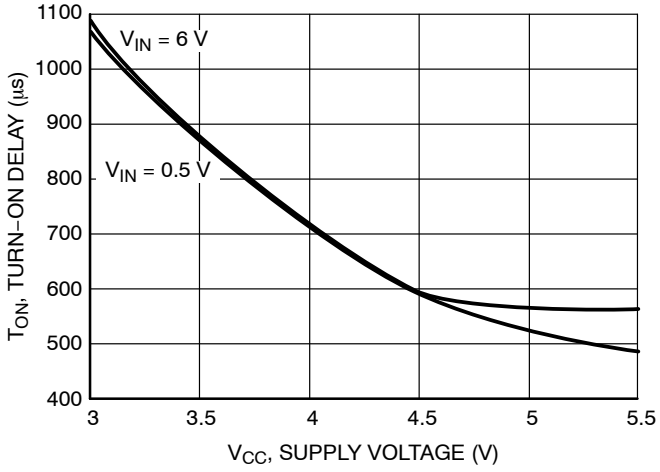


Figure 10. Turn−On Delay vs. Supply Voltage

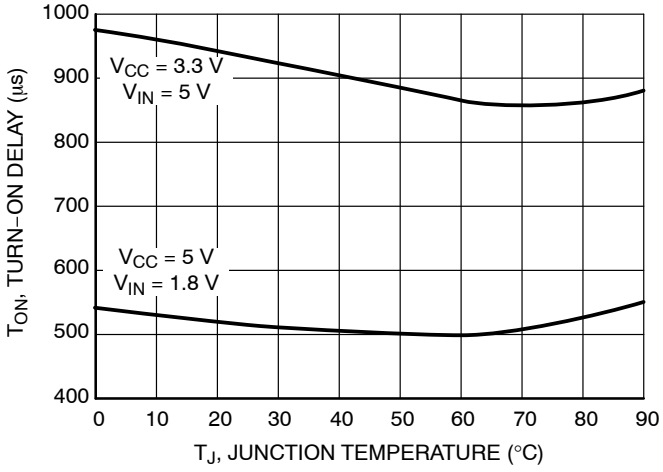


Figure 11. Turn−On Delay vs. Temperature

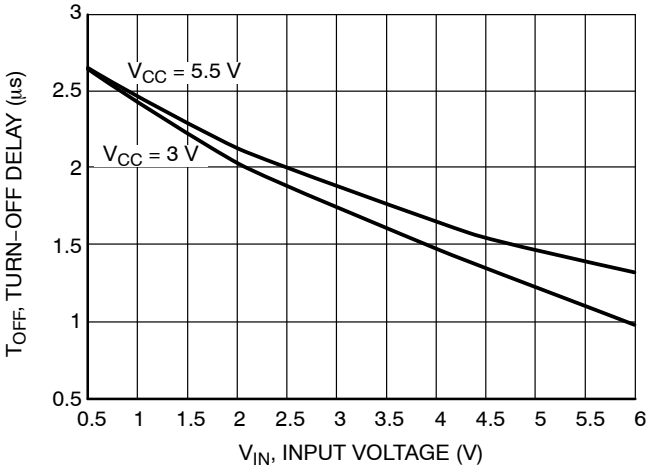


Figure 12. Turn−Off Delay vs. Input Voltage

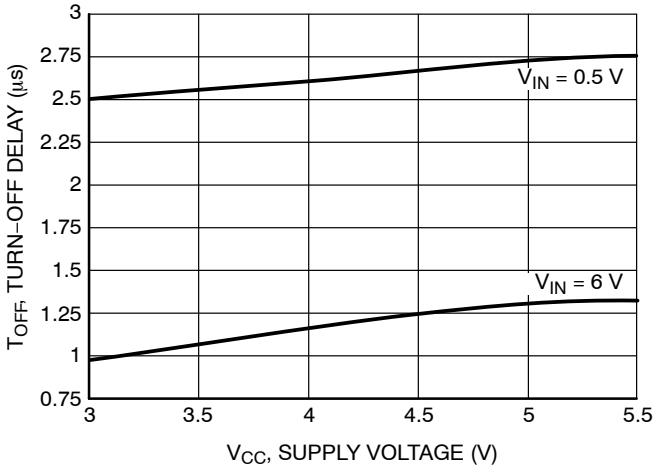


Figure 13. Turn−Off Delay vs. Supply Voltage

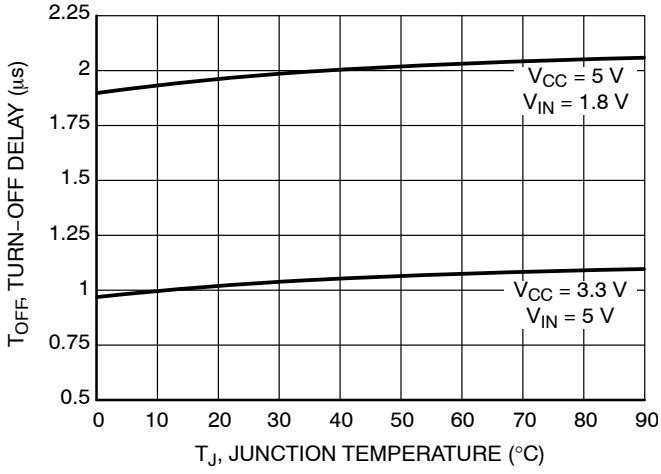


Figure 14. Turn−Off Delay vs. Temperature

TYPICAL CHARACTERISTICS

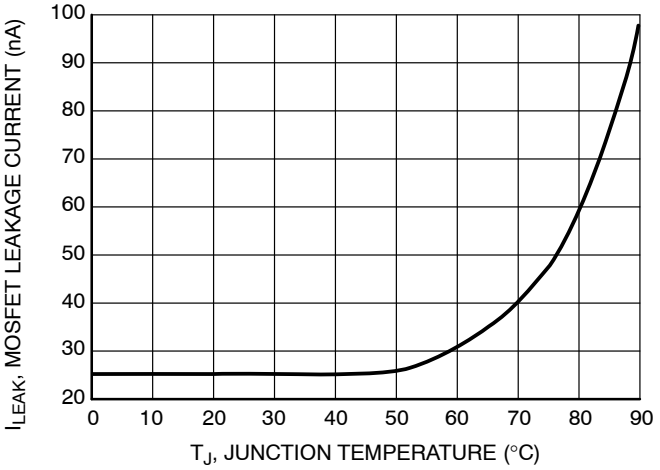


Figure 15. MOSFET Leakage Current vs. Temperature

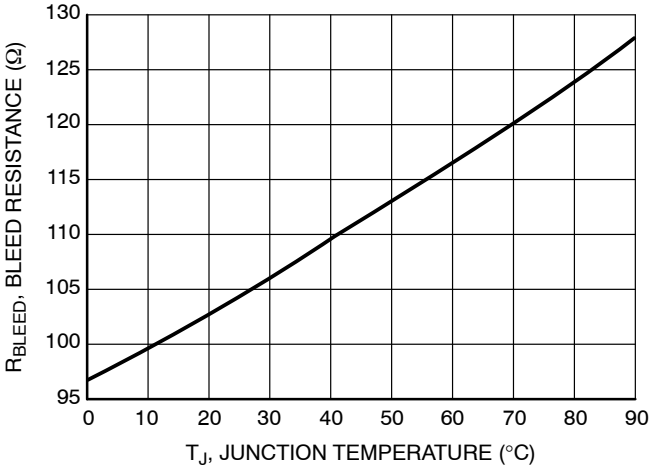


Figure 16. Bleed Resistance vs. Temperature

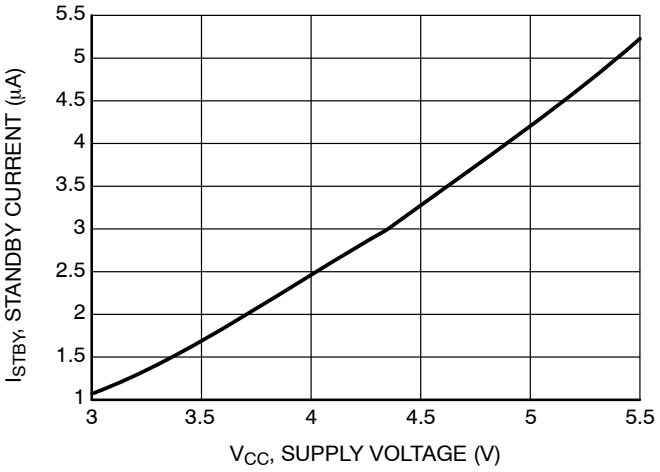


Figure 17. Standby Current vs. Supply Voltage

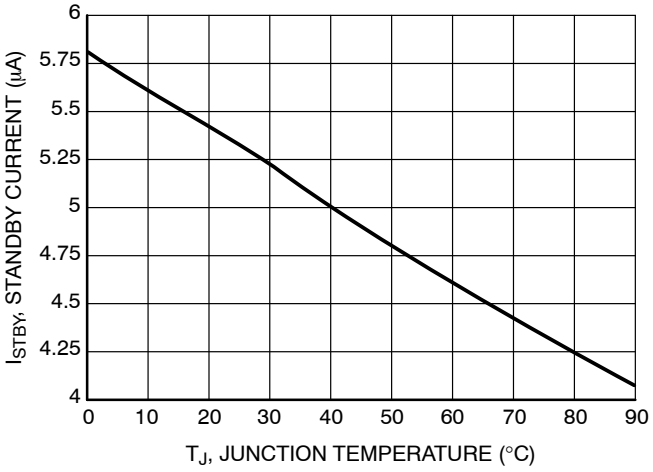


Figure 18. Standby Current vs. Temperature



Figure 19. Turn−on Response
(V_{CC} = 3.3 V, V_{IN} = 5.0 V, R_L = 10 Ω, C_L = 0.1 μF)

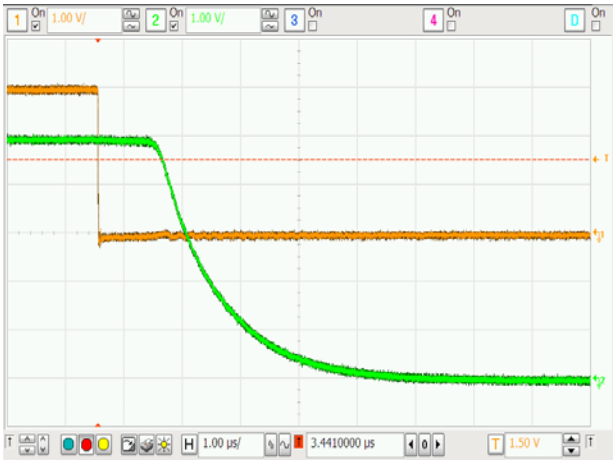


Figure 20. Turn−off Response
(V_{CC} = 3.3 V, V_{IN} = 5.0 V, R_L = 10 Ω, C_L = 0.1 μF)

APPLICATIONS INFORMATION

On−Resistance

The MOSFET gate voltage in the NCP4545 is driven by a charge pump in the controller circuit. The output voltage of the charge pump is dependent on the voltage on V_{CC}. The R_{ON} of the MOSFET is in turn dependent on its V_{GS}. Care must be taken to ensure a sufficient V_{CC} voltage is used to create the desired R_{ON} given the anticipated input voltage.

Enable Control

The NCP4545 has two separate part numbers, NCP4545IMNTWG and NCP4545IMNTWG-L, that only differ in the polarity of the enable control.

The NCP4545IMNTWG 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 GND on the EN pin ensures that the MOSFET will be disabled when not being driven.

The NCP4545IMNTWG-L 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.

Parametric Adjustments

The NCP4545 can be used in several configurations depending on the need to control turn-on delay, slew rate, and bleed resistance. Default values of each parameter are built into the part without the requirement of external components. This configuration is shown above in Figure 1.

Figures 21 and 22 show alternate configurations where external components are used to modify the turn-on delay, slew rate, and total bleed resistance.

Figure 21 shows an external capacitor, C_{COMBO}, connected from the V_{OUT} pin to both the DELAY and SR pins. This allows for one external capacitor to be used to modify the turn-on delay and slew rate. Note that the value of C_{COMBO} is used in Equations 1 and 2 (below) in place of C_{DEL} and C_{SR} respectively.

Figure 22 shows the use of two external capacitors for independent control of the turn-on delay and slew rate.

Turn−On Delay

The NCP4545 provides a time delay between the input transition on EN to the MOSFET turning on. The turn-on delay can be increased with an external capacitor added between the DELAY pin and either ground or the V_{OUT} pin as shown in Figures 21 and 22.

The total delay is calculated by adding the default turn-on delay to a delta term which is calculated as follows:

$$\Delta t = K_{DEL} * C_{DEL} \qquad \text{(eq. 1)}$$

where K_{DEL} is a constant and C_{DEL} is the off-chip capacitance added between the DELAY pin to either ground or the V_{OUT} pin (see table below). When no external capacitor is present, the delay will be the specified default turn-on delay.

Slew Rate Control

The NCP4545 is equipped with controlled output slew rate which provides soft start functionality. This limits the inrush current caused by capacitor charging and enables this device to be used in hot swapping applications. The slew rate can be decreased with an external capacitor added between the SR pin and the V_{OUT} pin as shown in Figures 21 and 22.

The slew rate can be calculated as follows:

$$SR = \frac{K_{SR}}{C_{SR} + C_{CHIP}} \qquad \text{(eq. 2)}$$

where K_{SR} is a constant, C_{SR} is the off-chip capacitance added between the SR pin and the V_{OUT} pin, and C_{CHIP} is the on-chip capacitance (see table below). Note that this equation is only valid for $C_{SR} \geq 470$ pF. When no external capacitor is present, the slew rate will be the specified default slew rate.

Load Bleed

The NCP4545 has an on−chip bleed resistor that can be 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 which 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. The total bleed resistance can be increased by adding a resistor between the BLEED pin and the V_{OUT} pin as shown in Figures 21 and 22. If the load bleed function is not desired, the BLEED pin should be tied to ground or left floating.

SLEW RATE AND TURN−ON DELAY

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Turn−on Delay Constant		K_{DEL}		1.77		MΩ
External Delay Capacitance (Note 13)	Between DEL pin and GND	C_{DEL}			10	nF
Slew Rate Constant		K_{SR}		1.42		μA
External Slew Rate Capacitance (Note 13)	Between SR pin and V_{OUT} pin	C_{SR}			2	nF
Internal Slew Rate Capacitance		C_{CHIP}		150		pF
External Combo Capacitance (Note 13)	Between SR & DEL pins and V_{OUT} pin	C_{COMBO}			2	nF

13. Recommended range, larger values may be used but may degrade the performance of the part

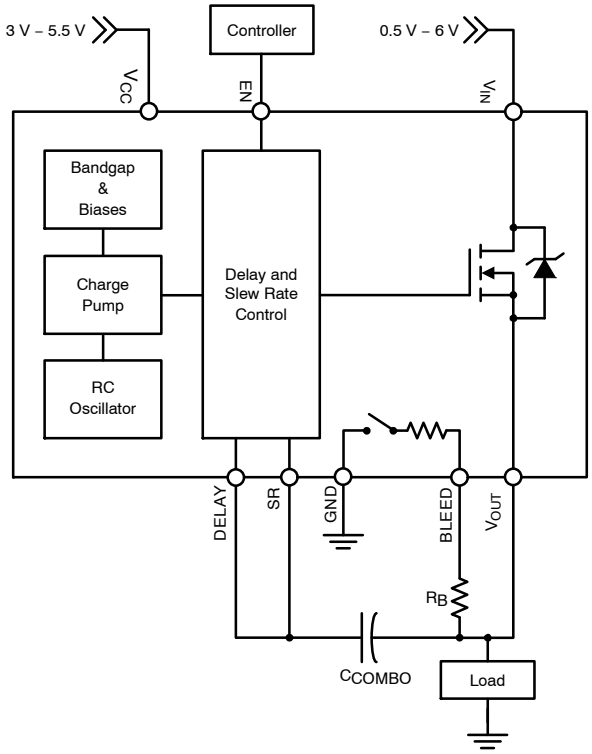


Figure 21. Example Application – External bleed resistor with single−capacitor adjustment of turn−on delay and slew rate.

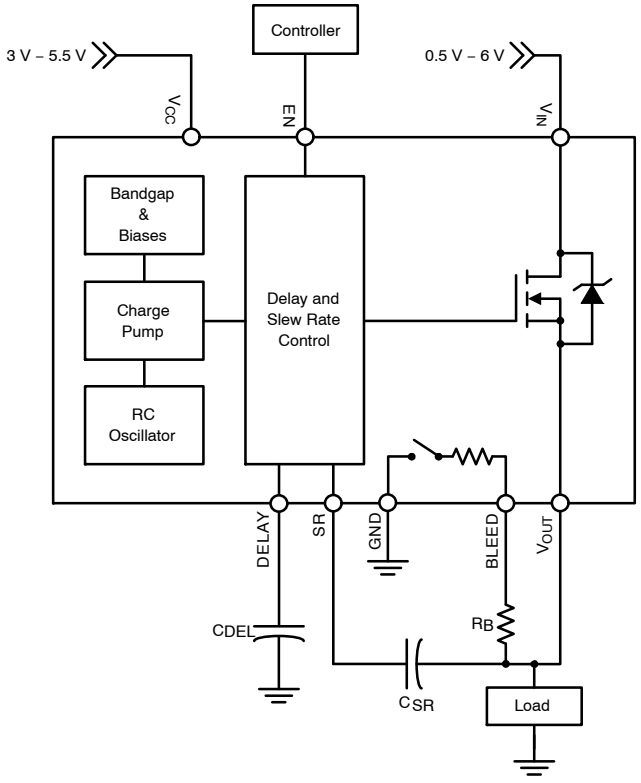
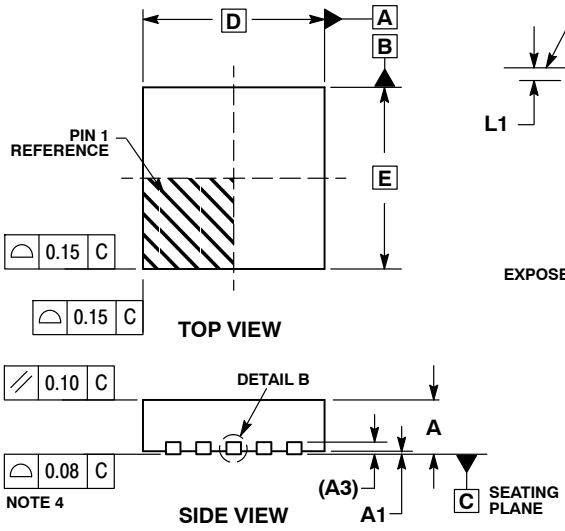
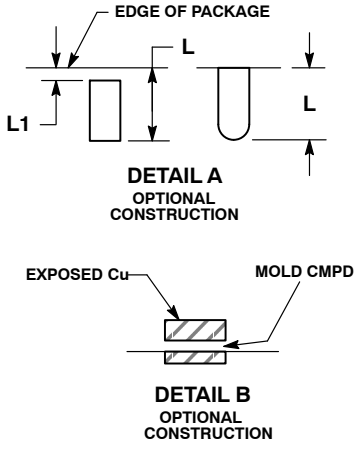


Figure 22. Example Application – External bleed resistor with independent adjustment of turn−on delay and slew rate.

PACKAGE DIMENSIONS

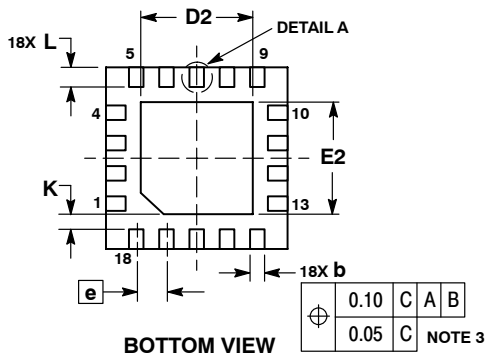
QFN18, 3x3, 0.5P
CASE 485BF
ISSUE O



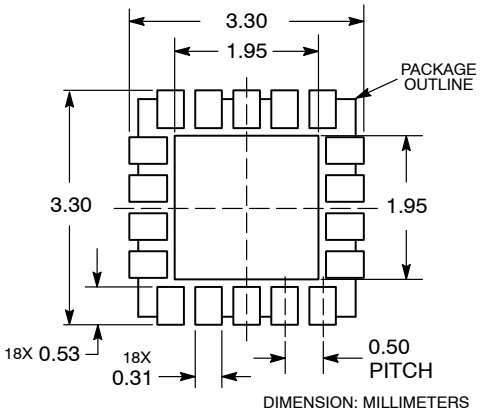


NOTES:
1. DIMENSIONS AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

	MILLIMETERS	
DIM	MIN	MAX
A	0.80	1.00
A1	0.00	0.05
A3	0.20 REF	
b	0.18	0.30
D	3.00 BSC	
D2	1.75	1.95
E	3.00 BSC	
E2	1.75	1.95
e	0.50 BSC	
K	0.20	---
L	0.275	0.375
L1	0.00	0.15



RECOMMENDED MOUNTING FOOTPRINT



DIMENSION: 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.

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