ecoSWITCH™ Advanced Load Management

Controlled Load Switch with Low R_{ON}

NCP45560

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}
- Input Voltage Range 0.5 V to 13.5 V
- Soft-Start via Controlled Slew Rate
- Adjustable Slew Rate Control
- Power Good Signal
- Thermal Shutdown
- Undervoltage Lockout
- Short-Circuit Protection
- Extremely Low Standby Current
- Load Bleed (Quick Discharge)
- This is a Pb−Free Device

Typical Applications

- Portable Electronics and Systems
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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	

Table 5. SWITCHING CHARACTERISTICS (T_J = 25°

TYPICAL CHARACTERISTICS

(T_J = 25°C UNLESS OTHERWISE SPECIFIED)

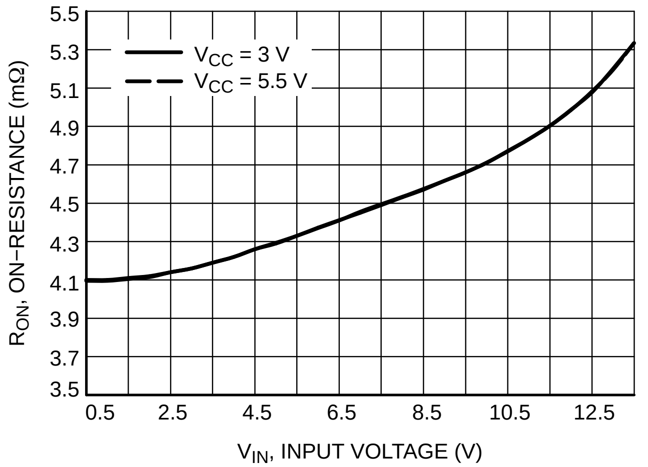


Figure 3. On−Resistance vs. Input Voltage

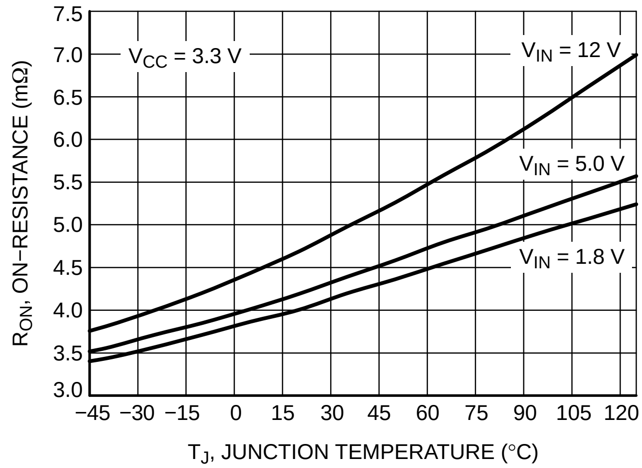


Figure 4. On−Resistance vs. Temperature

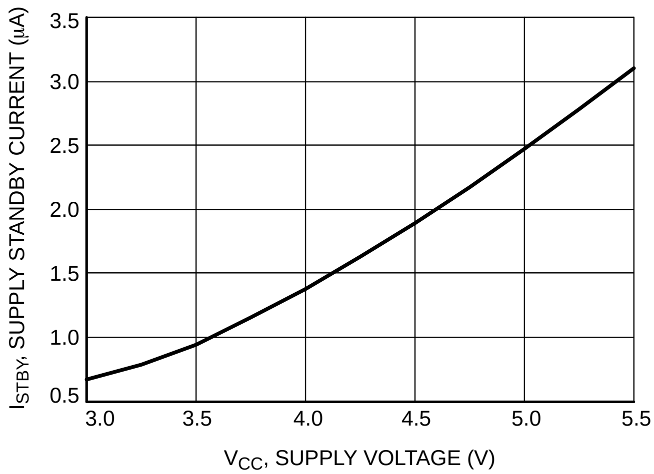


Figure 5. Supply Standby Current vs. Supply Voltage

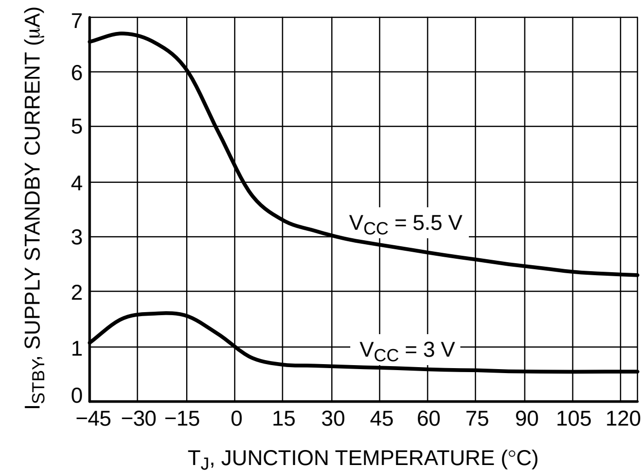


Figure 6. Supply Standby Current vs. Temperature

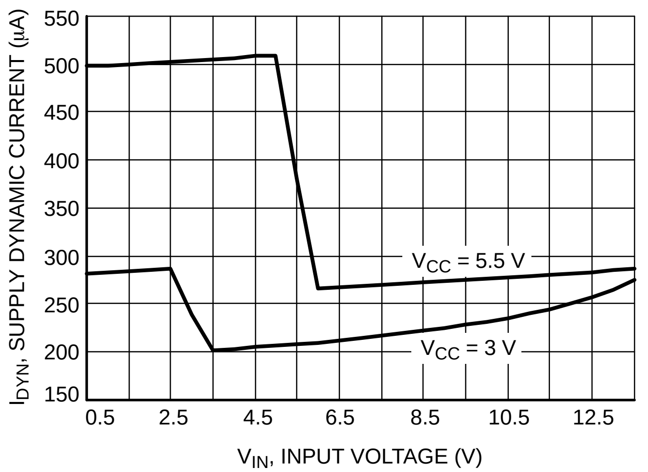


Figure 7. Supply Dynamic Current vs. Input Voltage

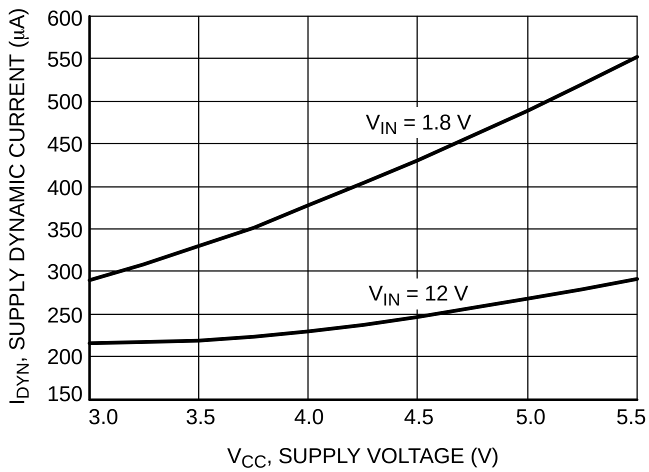


Figure 8. Supply Dynamic Current vs. Supply Voltage

TYPICAL CHARACTERISTICS

(T_J = 25°C UNLESS OTHERWISE SPECIFIED)

45 75 105

T_J, JUNCTION TEMPERATURE (°C)

Figure 9. Supply Dynamic Current vs. Temperature

V_{CC}, SUPPLY VOLTAGE (V)

Figure 10. Bleed Resistance vs. Supply Voltage

TYPICAL CHARACTERISTICS

(T_J = 25°C UNLESS OTHERWISE SPECIFIED)

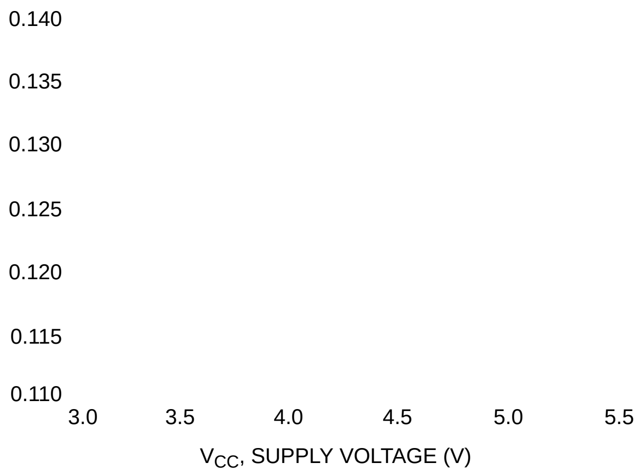


Figure 15. PG Output Low Voltage vs. Supply Voltage

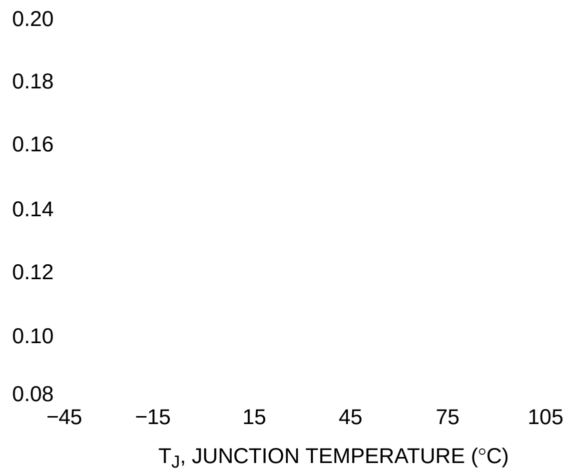


Figure 16. PG Output Low Voltage vs. Temperature

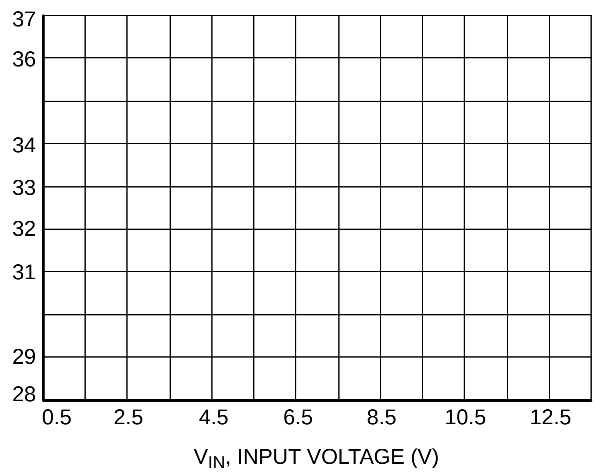


Figure 17. Slew Rate Control Constant vs. Input Voltage

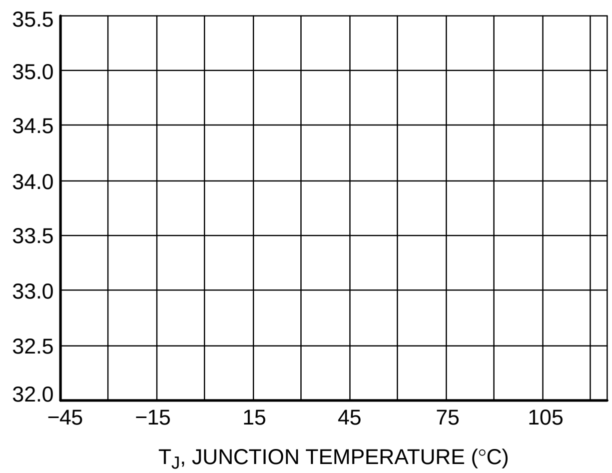


Figure 18. Slew Rate Control Constant vs. Temperature

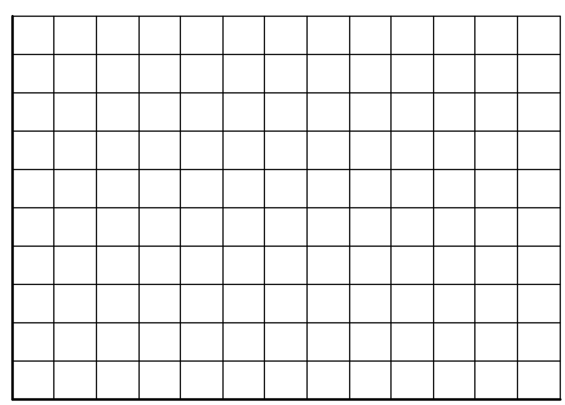


Figure 19. Short−0 Tc80ef5TJTT2 1 Tf.5832 0 TD-000c.0

TYPICAL CHARACTERISTICS

(T_J = 25

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 device allows for enabling the MOSFET in an active−high configuration. When the V_{CC} supply pin has an adequate voltage applied and the EN pin is at a logic high level, 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 device allows for enabling the MOSFET in an active−low configuration. When the V_{CC} supply pin has an adequate voltage applied and the EN pin is at a logic low level, 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.

Power Sequencing

The NCP45560 devices will function with any power sequence, but the output turn−on delay performance may vary from what is specified. To achieve the specified performance, there are two recommended power sequences:

1. $V_{CC} \rightarrow V_{IN} \rightarrow V_{EN}$
2. $V_{IN} \rightarrow V_{CC} \rightarrow V_{EN}$

V_{CC} must be at 2 V or higher when EN is asserted to ensure that the enable is latched properly for correct operation. If EN comes up before V_{CC} reaches 2 V, then the EN may not take effect.

Load Bleed (Quick Discharge)

The NCP45560 devices have an internal bleed resistor, R_{BLEED}, which 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. The MOSFET and the bleed switch are never concurrently active.

It is required that the BLEED pin be connected to V_{OUT} either directly (as shown in Figure 31) or through an external resistor, R_{EXT} (as shown in Figure 30). R_{EXT} should not exceed 1 kΩ and can be used to increase the total bleed resistance.

Care must be taken to ensure that the power dissipated across R_{BLEED} is kept at a safe level. The maximum continuous power that can be dissipated across R_{BLEED} is 0.4 W. R_{EXT} can be used to decrease the amount of power dissipated across R_{BLEED}.

Power Good

The NCP45560 devices have a power good output (PG) that can be used to indicate when the gate of the MOSFET is fully charged. The PG pin is an active−high, open−drain output that requires an external pull up resistor, R_{PG}, greater than or equal to 1 kΩ to an external voltage source, V_{TERM}, compatible with input levels of other devices connected to this pin (as shown in Figures 30 and 31).

The power good output can be used as the enable signal for other active−high devices in the system (as shown in Figure 32). This allows for guaranteed by design power sequencing and reduces the number of enable signals needed from the system controller. If the power good feature is not used in the application, the PG pin should be tied to GND.

Slew Rate Control

The NCP45560 devices are 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 swap applications.

The slew rate can be decreased with an external capacitor added between the SR pin and ground (as shown in Figures 30 and 31). 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. 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. The SR pin can be left floating if the slew rate does not need to be decreased.

Short–Circuit Protection

The NCP45560 devices are 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 charged.

Once active, the circuitry monitors the difference in the voltage on the V_{IN} pin and the voltage on the BLEED pin. 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 (as shown in Figure 31) or through a resistor, R_{EXT} (as shown in Figure 30), which should not exceed 1 kΩ. With the BLEED pin connected to V_{OUT}, the short−circuit protection is able to monitor the voltage drop across the MOSFET.

If the voltage drop across the MOSFET is greater than or 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. The current through the MOSFET that will cause a short−circuit event can be calculated by dividing the short−circuit protection threshold by the expected on−resistance of the MOSFET.

Thermal Shutdown

The thermal shutdown of the NCP45560 devices 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 devices turns the MOSFET off and activates the load bleed when the input voltage, V_{IN}, is less than or equal to the undervoltage lockout threshold. This circuitry is disabled when EN is not active to reduce standby current.

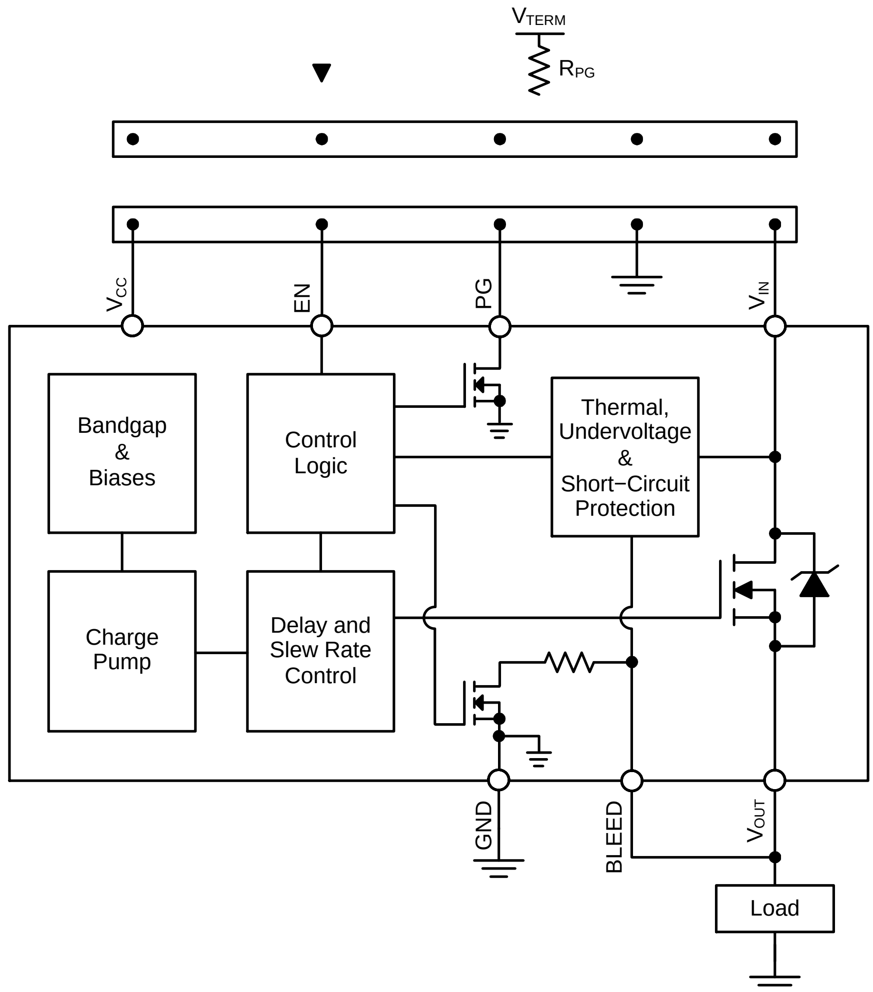
If the V_{IN} voltage rises above the undervoltage lockout threshold, and EN remains active, the MOSFET will be turned on in a controlled fashion with the normal output turn−on delay and slew rate.

Capacitive Load

The peak in−rush current associated with the initial charging of the application load capacitance needs to stay below the specified I_{MAX}. CL (capacitive load) should be less than Cmax as defined by the following equation:

$$C_{max} = \frac{I_{max}}{SR_{typ}} \qquad \text{(eq. 2)}$$

Where I_{MAX} is the maximum load current, and SRtyp is the typical default slew rate when no external load capacitor is added to the SR pin.


VTERM
RPG
VCC
EN
PG
VIN
Bandgap
&
Biases
Control
Logic
Thermal,
Undervoltage
&
Short−Circuit
Protection
Charge
Pump
Delay and
Slew Rate
Control
GND
BLEED
VOUT
Load

DFN12 3x3, 0.5P
CASE 506CD
ISSUE A

DATE 18 FEB 2014

SCALE 4:1

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.