

NCP360, NCV360

USB Positive Overvoltage Protection Controller with Internal PMOS FET and Status FLAG

The NCP360 disconnects systems at its output when wrong VBUS operating conditions are detected at its input. The system is positive overvoltage protected up to +20 V.

Thanks to an integrated PMOS FET, no external device is necessary, reducing the system cost and the PCB area of the application board.

The NCP360 is able to instantaneously disconnect the output from the input if the input voltage exceeds the overvoltage threshold (OVLO).

The NCP360 provides a negative going flag ($\overline{\text{FLAG}}$) output, which alerts the system that a fault has occurred.

In addition, the device has ESD-protected input (15 kV Air) when bypassed with a 1 μF or larger capacitor.

Features

- Very Fast Protection, Up to 20 V, with 25 μA Current Consumption
- On-chip PMOS Transistor
- Overvoltage Lockout (OVLO)
- Undervoltage Lockout (UVLO)
- Alert $\overline{\text{FLAG}}$ Output
- $\overline{\text{EN}}$ Enable Pin
- Thermal Shutdown
- Compliance to IEC61000-4-2 (Level 4)
 - 8 kV (Contact)
 - 15 kV (Air)
- ESD Ratings: Machine Model = B
Human Body Model = 2
- 6 Lead UDFN 2x2 mm Package
- 5 Lead TSOP 3x3 mm Package
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These are Pb-Free Devices

Applications

- USB Devices
- Mobile Phones
- Peripheral
- Personal Digital Applications
- MP3 Players



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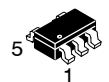
MARKING DIAGRAMS



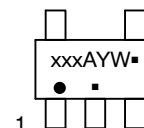
UDFN6
MU SUFFIX
CASE 517AB



M = Date Code
▪ = Pb-Free Package



TSOP-5
SN SUFFIX
CASE 483



A = Assembly Location
Y = Year
W = Work Week
▪ = Pb-Free Package

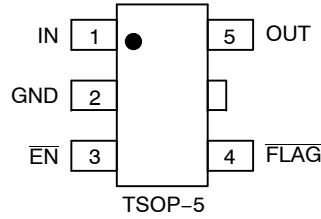
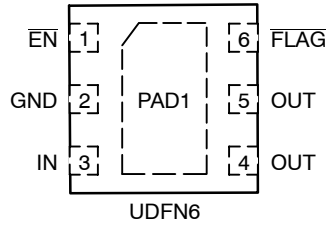
(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering, marking and shipping information in the package dimensions section on page 11 of this data sheet.

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PIN CONNECTIONS



(Top Views)

PIN FUNCTION DESCRIPTION (UDFN6 Package)

| Pin No. | Name | Type | Description |
|---------|--------------------------|--------|---|
| 1 | $\overline{\text{EN}}$ | INPUT | Enable Pin. The device enters in shutdown mode when this pin is tied to a high level. In this case the output is disconnected from the input. To allow normal functionality, the $\overline{\text{EN}}$ pin shall be connected to GND or to a I/O pin. This pin does not have an impact on the fault detection. |
| 2 | GND | POWER | Ground |
| 3 | IN | POWER | Input Voltage Pin. This pin is connected to the VBUS. A 1 μF low ESR ceramic capacitor, or larger, must be connected between this pin and GND. |
| 4, 5 | OUT | OUTPUT | Output Voltage Pin. The output is disconnected from the VBUS power supply when the input voltage is above OVLO threshold or below UVLO threshold. A 1 μF capacitor must be connected to these pins. The two OUT pins must be hardwired to common supply. |
| 6 | $\overline{\text{FLAG}}$ | OUTPUT | Fault Indication Pin. This pin allows an external system to detect a fault on VBUS pin. The $\overline{\text{FLAG}}$ pin goes low when input voltage exceeds OVLO threshold. Since the $\overline{\text{FLAG}}$ pin is open drain functionality, an external pull up resistor to V_{CC} must be added. |
| - | PAD1 | POWER | Exposed Pad. Can be connected to GND or isolated plane. Must be used to thermal dissipation. |

PIN FUNCTION DESCRIPTION (TSOP-5 Package)

| Pin No. | Name | Type | Description |
|---------|--------------------------|--------|---|
| 1 | IN | POWER | Input Voltage Pin. This pin is connected to the VBUS. A 1 μF low ESR ceramic capacitor, or larger, must be connected between this pin and GND. |
| 2 | GND | POWER | Ground |
| 3 | $\overline{\text{EN}}$ | INPUT | Enable Pin. The device enters in shutdown mode when this pin is tied to a high level. In this case the output is disconnected from the input. To allow normal functionality, the $\overline{\text{EN}}$ pin shall be connected to GND or to a I/O pin. This pin does not have an impact on the fault detection. |
| 4 | $\overline{\text{FLAG}}$ | OUTPUT | Fault Indication Pin. This pin allows an external system to detect a fault on VBUS pin. The $\overline{\text{FLAG}}$ pin goes low when input voltage exceeds OVLO threshold. Since the $\overline{\text{FLAG}}$ pin is open drain functionality, an external pull up resistor to V_{CC} must be added. |
| 5 | OUT | OUTPUT | Output Voltage Pin. The output is disconnected from the VBUS power supply when the input voltage is above OVLO threshold or below UVLO threshold. A 1 μF capacitor must be connected to this pin. |

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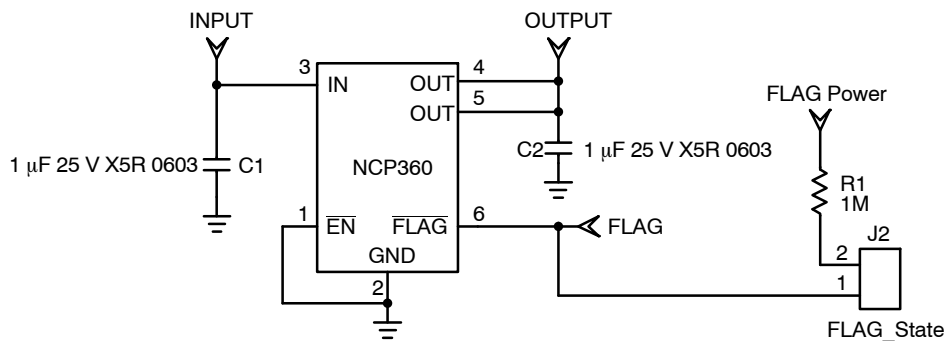


Figure 1. Typical Application Circuit (UDFN Pinout)

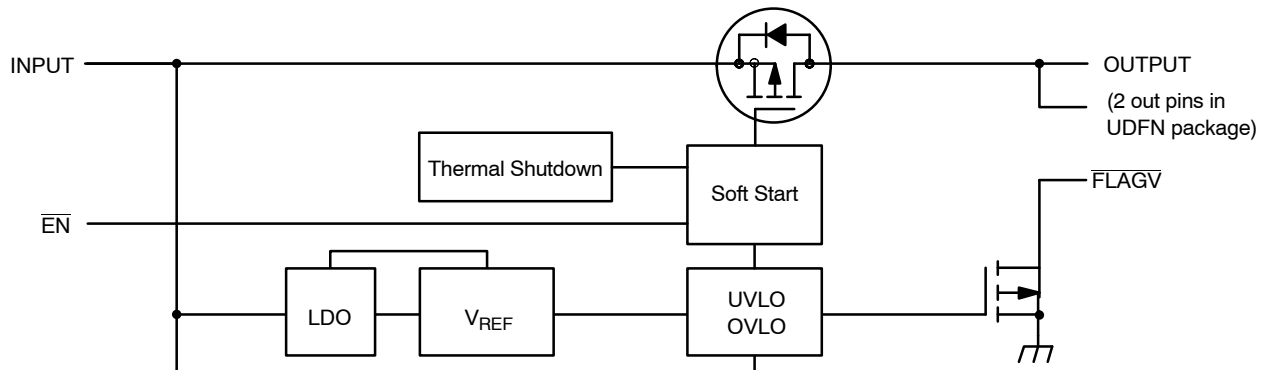


Figure 2. Functional Block Diagram

NCP360, NCV360

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|--|-----------------|------------------------------------|----------------|
| Minimum Voltage (IN to GND) | $V_{min_{in}}$ | -0.3 | V |
| Minimum Voltage (All others to GND) | V_{min} | -0.3 | V |
| Maximum Voltage (IN to GND) | $V_{max_{in}}$ | 21 | V |
| Maximum Voltage (All others to GND) | V_{max} | 7.0 | V |
| Maximum Current from Vin to Vout (PMOS) (Note 1) | I_{max} | 600 | mA |
| Thermal Resistance, Junction-to-Air (Note 2) | $R_{\theta JA}$ | 305 260 | °C/W |
| | | | TSOP-5 UDFN |
| Operating Ambient Temperature Range | T_A | -40 to +85 | °C |
| Storage Temperature Range | T_{stg} | -65 to +150 | °C |
| Junction Operating Temperature | T_J | 150 | °C |
| ESD Withstand Voltage (IEC 61000-4-2) Human Body Model (HBM), Model = 2 (Note 3) Machine Model (MM) Model = B (Note 4) | V_{esd} | 15 Air, 8.0 Contact 2000 200 | kV V V |
| Moisture Sensitivity | MSL | Level 1 | - |

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. With minimum PCB area. By decreasing $R_{\theta JA}$, the current capability increases. See PCB recommendation page 9.
2. $R_{\theta JA}$ is highly dependent on the PCB heat sink area (connected to PAD1, UDFN). See PCB Recommendations.
3. Human Body Model, 100 pF discharged through a 1.5 k Ω resistor following specification JESD22/A114.
4. Machine Model, 200 pF discharged through all pins following specification JESD22/A115.
5. Compliant with JEDEC Latch-up Test, up to maximum voltage range.

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ELECTRICAL CHARACTERISTICS

(Min/Max limits values ($-40^{\circ}\text{C} < T_A < +85^{\circ}\text{C}$) and $V_{in} = +5.0\text{ V}$. Typical values are $T_A = +25^{\circ}\text{C}$, unless otherwise noted.)

| Characteristic | Symbol | Conditions | Min | Typ | Max | Unit |
|-----------------------------------|----------------------|---|----------------------------|------------------------------|--------------------------|---------------|
| Input Voltage Range | V_{in} | | 1.2 | | 20 | V |
| Undervoltage Lockout Threshold | UVLO | V_{in} falls below UVLO threshold | 2.85 | 3.0 | 3.15 | V |
| Undervoltage Lockout Hysteresis | UVLO _{hyst} | MU/SN, SNAE SNAF, SNAI | 50 30 | 70 50 | 90 70 | mV |
| Overvoltage Lockout Threshold | OVLO | V_{in} rises above OVLO threshold MU/SN SNAE SNAF SNAI | 5.43 6.0 6.75 7.0 | 5.675 6.25 7.07 7.2 | 5.9 6.5 7.4 7.4 | V |
| Overvoltage Lockout Hysteresis | OVLO _{hyst} | | 50 | 100 | 125 | mV |
| V_{in} versus V_{out} Dropout | V_{drop} | $V_{in} = 5\text{ V}$, $I_{charge} = 500\text{ mA}$ | | 105 | 200 | mV |
| Supply Quiescent Current | I_{dd} | No Load, $V_{in} = 5.25\text{ V}$ | | 24 | 35 | μA |
| OVLO Supply Current | $I_{dd_{ovlo}}$ | $V_{in} = 7\text{ V}$ $V_{in} = 8\text{ V}$ MU/SN, SNAE SNAF, SNAI | | 50 50 | 85 85 | μA |
| Output Off State Current | I_{std} | $V_{in} = 5.25\text{ V}$, $EN = 1.2\text{ V}$ | | 26 | 37 | μA |
| FLAG Output Low Voltage | $V_{ol_{flag}}$ | $V_{in} > OVLO$, Sink 1 mA on \overline{FLAG} pin | | | 400 | mV |
| FLAG Leakage Current | FLAG _{leak} | \overline{FLAG} level = 5 V | | 5.0 | | nA |
| \overline{EN} Voltage High | V_{ih} | V_{in} from 3.3 V to 5.25 V | 1.2 | | | V |
| \overline{EN} Voltage Low | V_{il} | V_{in} from 3.3 V to 5.25 V | | | 0.4 | V |
| EN Leakage Current | EN _{leak} | $EN = 5.5\text{ V}$ or GND | | 170 | | nA |

TIMINGS

| | | | | | | |
|------------------------------|--------------|--|--|-----|-----|--------------------|
| Start Up Delay | t_{on} | From V_{in} : (0 to (OVLO - 300 mV) < V_{in} < OVLO) to $V_{out} = 0.8 \times V_{in}$. Rise time < 4 μs See Figures 3&9 | | 4.0 | 15 | ms |
| FLAG going up Delay | t_{start} | From $V_{in} > UVLO$ to $\overline{FLAG} = 1.2\text{ V}$, See Fig 3 & 10 | | 3.0 | | μs |
| Output Turn Off Time | t_{off} | From $V_{in} > OVLO$ to $V_{out} \leq 0.3\text{ V}$, See Fig 4 & 11 V_{in} increasing from normal operation to >OVLO at 1V/ μs . No output capacitor. | | 0.8 | 1.5 | μs |
| Alert Delay | t_{stop} | From $V_{in} > OVLO$ to $\overline{FLAG} \leq 0.4\text{ V}$, See Fig 4 & 12 V_{in} increasing from normal operation to >OVLO at 1V/ μs | | 1.0 | 2.0 | μs |
| Disable Time | t_{dis} | From $\overline{EN} 0.4$ to 1.2V to $V_{out} \leq 0.3\text{V}$, See Fig 5 & 13 $V_{in} = 4.75\text{ V}$. No output capacitor. | | 2.0 | | μs |
| Thermal Shutdown Temperature | T_{sd} | | | 150 | | $^{\circ}\text{C}$ |
| Thermal Shutdown Hysteresis | T_{sdhyst} | | | 30 | | $^{\circ}\text{C}$ |

NOTE: Thermal Shutdown parameter has been fully characterized and guaranteed by design.

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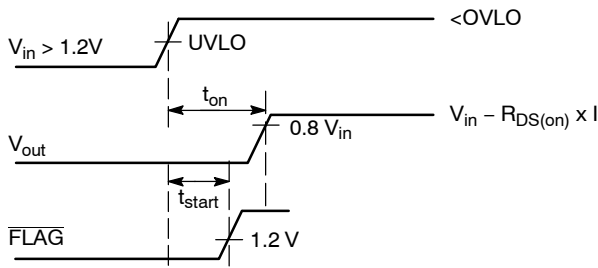


Figure 3. Start Up Sequence

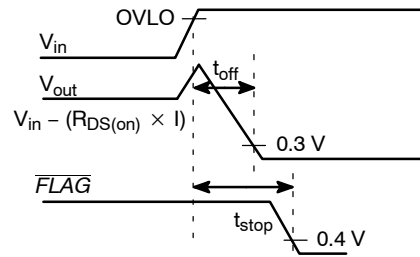


Figure 4. Shutdown on Over Voltage Detection

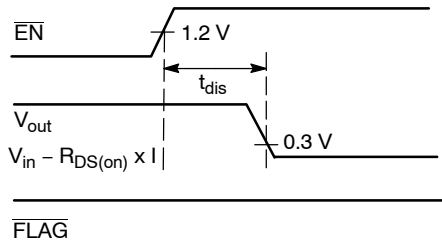


Figure 5. Disable on $\overline{EN} = 1$

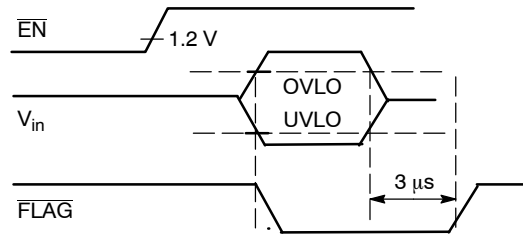


Figure 6. \overline{FLAG} Response with $\overline{EN} = 1$

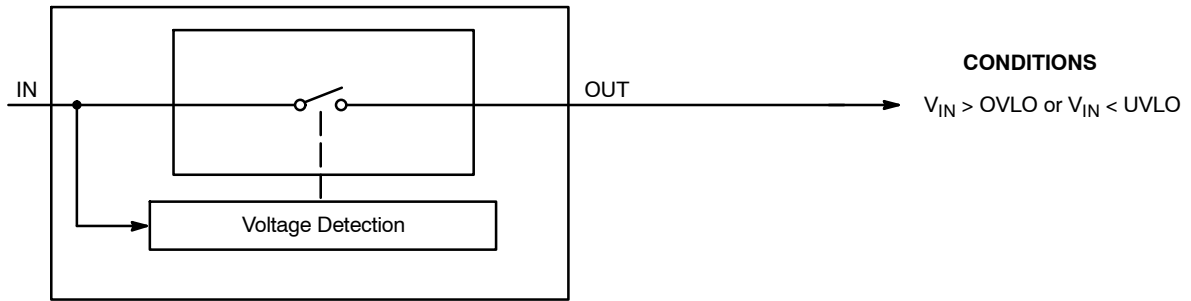


Figure 7.

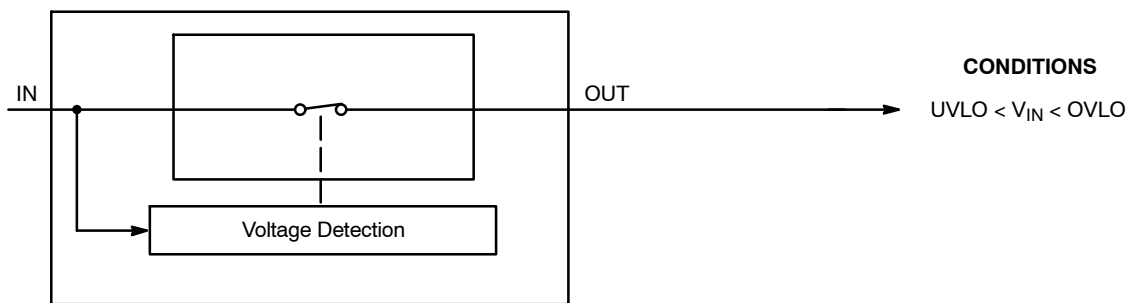


Figure 8.

TYPICAL OPERATING CHARACTERISTICS

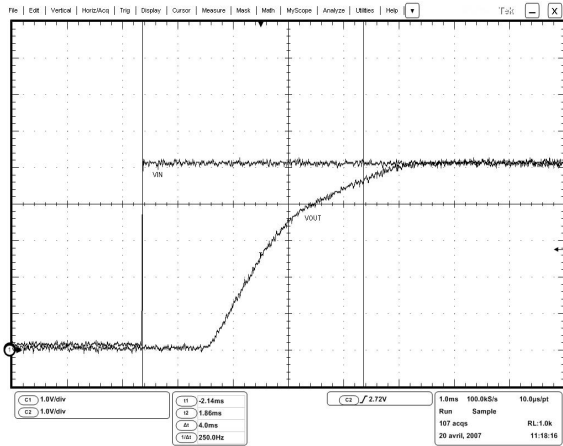


Figure 9. Startup
 $V_{in} = \text{Ch1}, V_{out} = \text{Ch3}$

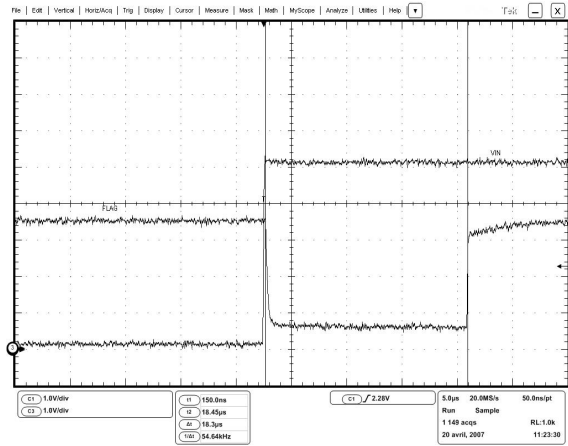


Figure 10. FLAG Going Up Delay
 $V_{in} = \text{Ch1}, \text{FLAG} = \text{Ch3}$

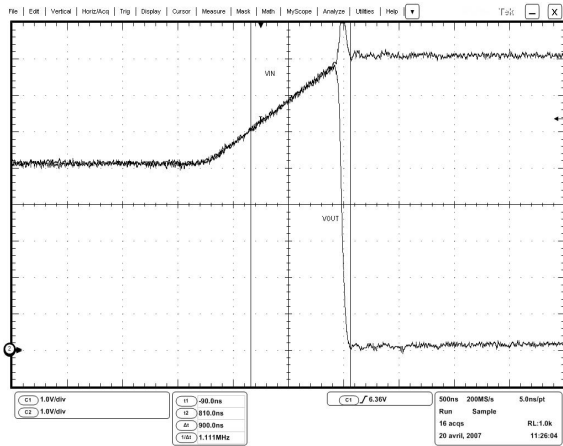


Figure 11. Output Turn Off Time
 $V_{in} = \text{Ch1}, V_{out} = \text{Ch2}$

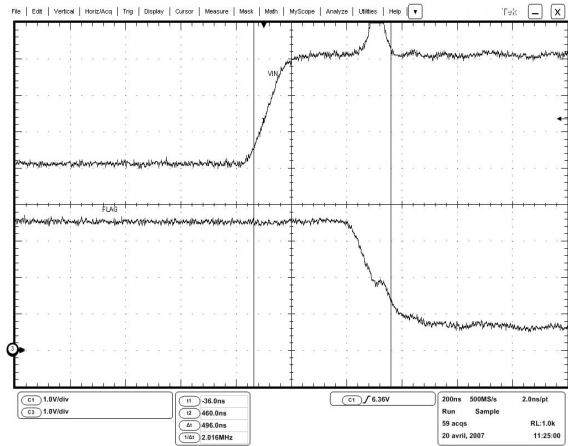


Figure 12. Alert Delay
 $V_{out} = \text{Ch1}, \text{FLAG} = \text{Ch3}$

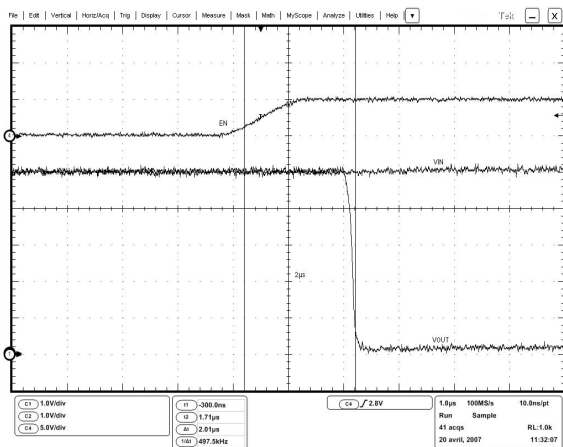


Figure 13. Disable Time
 $\text{EN} = \text{Ch1}, V_{out} = \text{Ch2}, \text{FLAG} = \text{Ch3}$

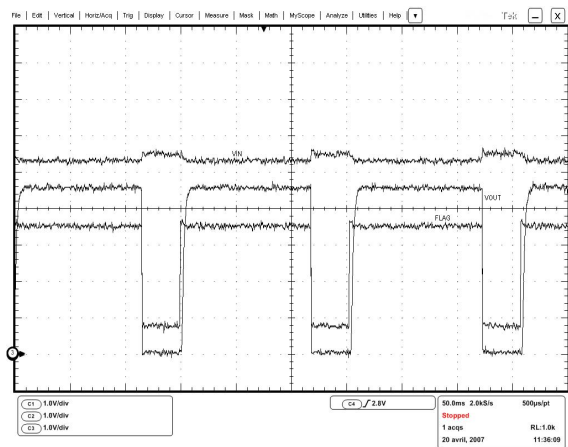


Figure 14. Thermal Shutdown
 $V_{in} = \text{Ch1}, V_{out} = \text{Ch2}, \text{FLAG} = \text{Ch3}$

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TYPICAL OPERATING CHARACTERISTICS

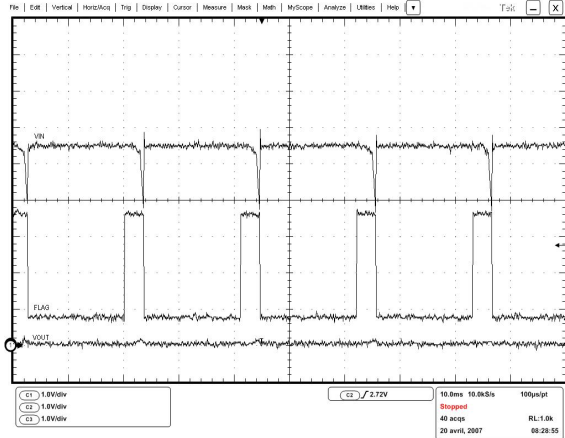


Figure 15. Direct Output Short Circuit

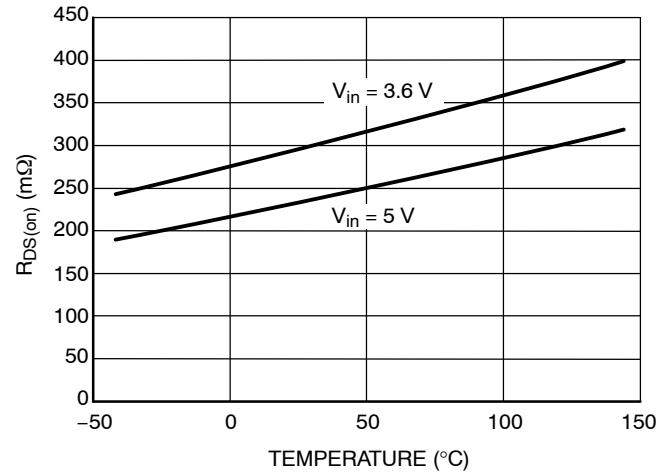


Figure 16. R_{DS(on)} vs. Temperature
(Load = 500 mA)

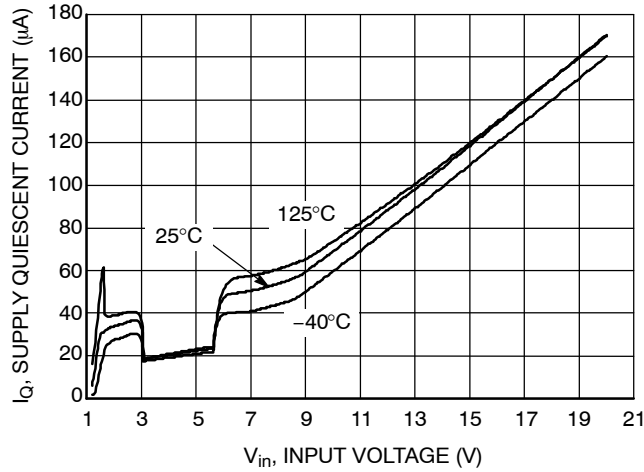


Figure 17. Supply Quiescent Current vs. V_{in}

In Operation

NCP360 provides overvoltage protection for positive voltage, up to 20 V. A PMOS FET protects the systems (i.e.: VBUS) connected on the V_{out} pin, against positive over-voltage. The Output follows the VBUS level until OVLO threshold is overtaken.

Undervoltage Lockout (UVLO)

To ensure proper operation under any conditions, the device has a built-in undervoltage lock out (UVLO) circuit. During V_{in} positive going slope, the output remains disconnected from input until V_{in} voltage is above 3.2 V nominal. The FLAGV output is pulled to low as long as V_{in} does not reach UVLO threshold. This circuit has a UVLO hysteresis to provide noise immunity to transient condition.

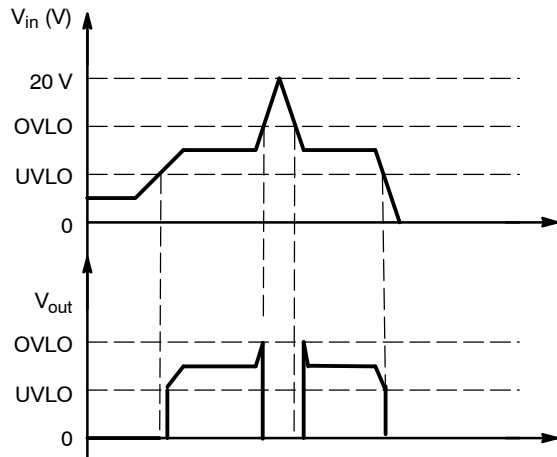


Figure 18. Output Characteristic vs. V_{in}

Overvoltage Lockout (OVLO)

To protect connected systems on V_{out} pin from overvoltage, the device has a built-in overvoltage lock out (OVLO) circuit. During overvoltage condition, the output remains disabled until the input voltage exceeds OVLO – Hysteresis.

FLAG output is tied to low until V_{in} is higher than OVLO. This circuit has a OVLO hysteresis to provide noise immunity to transient conditions.

FLAG Output

NCP360 provides a \overline{FLAG} output, which alerts external systems that a fault has occurred.

This pin is tied to low as soon the OVLO threshold is exceeded. When V_{in} level recovers normal condition, \overline{FLAG} is held high. The pin is an open drain output, thus a pull up resistor (typically 1 M Ω – Minimum 10 k Ω) must be provided to $V_{battery}$. \overline{FLAG} pin is an open drain output.

\overline{EN} Input

To enable normal operation, the \overline{EN} pin shall be forced to low or connected to ground. A high level on the pin disconnects OUT pin from IN pin. \overline{EN} does not overdrive an OVLO or UVLO fault.

Internal PMOS FET

NCP360 includes an internal PMOS FET to protect the systems, connected on OUT pin, from positive overvoltage. Regarding electrical characteristics, the R_{DSon} , during normal operation, will create low losses on V_{out} pin, characterized by V_{in} versus V_{out} dropout. (See Figure 16).

ESD Tests

NCP360 fully support the IEC61000-4-2, level 4 (Input pin, 1 μ F mounted on board).

That means, in Air condition, V_{in} has a ± 15 kV ESD protected input. In Contact condition, V_{in} has ± 8 kV ESD protected input.

Please refer to Fig 19 to see the IEC 61000-4-2 electrostatic discharge waveform.

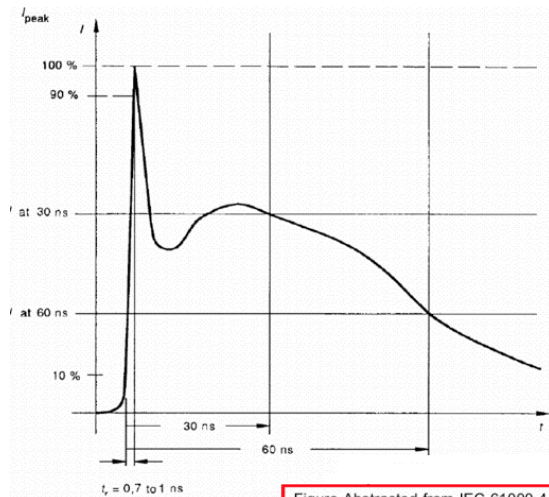


Figure 19.

PCB Recommendations

The NCP360 integrates a 500 mA rated PMOS FET, and the PCB rules must be respected to properly evacuate the heat out of the silicon. The UDFN PAD1 must be connected to ground plane to increase the heat transfer if necessary from an application standpoint. Of course, in any case, this pad shall be not connected to any other potential.

By increasing PCB area, the $R_{\theta JA}$ of the package can be decreased, allowing higher charge current to fill the battery.

Taking into account that internal bondings (wires between package and silicon) can handle up to 1 A (higher than thermal capability), the following calculation shows two different example of current capability, depending on PCB area:

- With 305°C/W (without PCB area), allowing DC current is 500 mA
- With 260°C/W (200 mm²), the charge DC current allows with a 85°C ambient temperature is:
 $I = \sqrt{(T_J - T_A) / (R_{\theta JA} \times R_{DSon})}$
 $I = 625$ mA

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In every case, we recommend to make thermal measurement on final application board to make sure of the final Thermal Resistance.

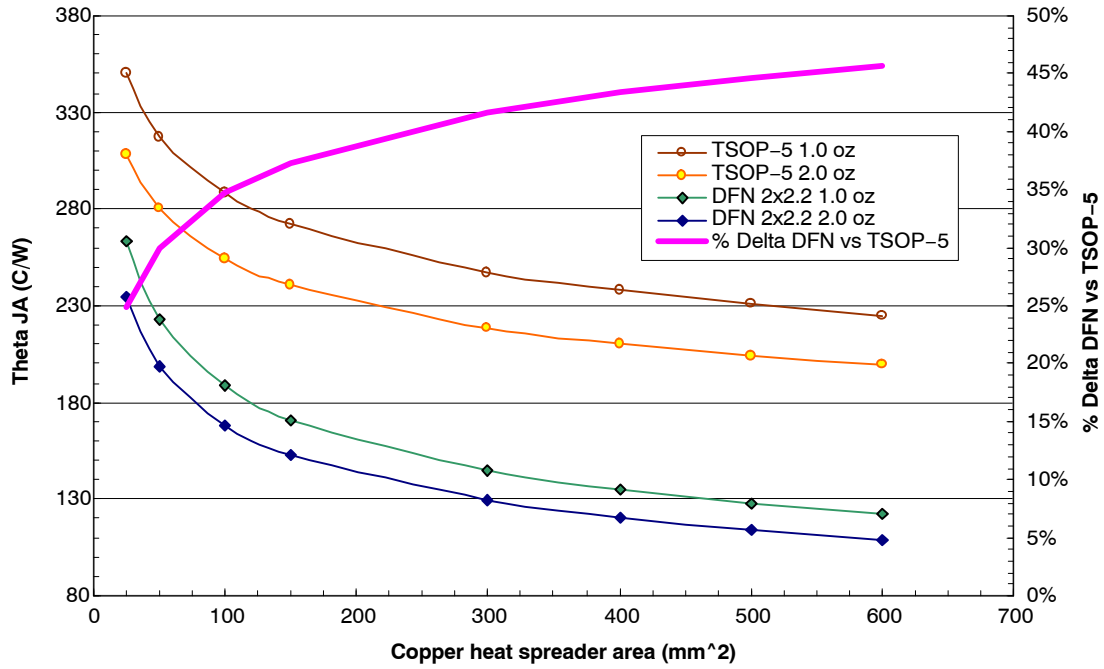


Figure 20. Thermal Resistance of UDFN 2x2 and TSOP Packages as a Function of PCB Area and Thickness

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ORDERING INFORMATION

| Device | Marking | Package | Shipping† |
|----------------|---------|---------------------|---------------------|
| NCP360MUTBG | ZD | UDFN6 (Pb-Free) | 3000 / Tape & Reel |
| NCP360MUTXG | ZD | UDFN6 (Pb-Free) | 10000 / Tape & Reel |
| NCP360SNT1G | SYA | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |
| NCP360SNAET1G | AAP | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |
| NCP360SNAFT1G | AA5 | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |
| NCP360SNAIT1G | ACE | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |
| NCV360SNT1G* | VUE | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |
| NCV360SNAET1G* | VEY | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |
| NCV360SNAFT1G* | VUM | TSOP-5 (Pb-Free) | 3000 / Tape & Reel |

†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.

*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements

SELECTION GUIDE

The NCP360 can be available in several undervoltage and overvoltage thresholds versions. Part number is designated as follows:

NCP360xxxxTxG



| Code | Contents |
|------|--|
| a | Package MU = UDFN SN = TSOP5 |
| b | UVLO Typical Threshold b: - = 3.0 V b: A = 3.0 V |
| c | OVLO Typical Threshold c: - = 5.675 V c: E = 6.25 V c: F = 7.07 V c: I = 7.2 V |
| d | Tape & Reel Type (parts per reel) d: 1 = 3000 d: B = 3000 d: X = 10000 |

MECHANICAL CASE OUTLINE

PACKAGE DIMENSIONS

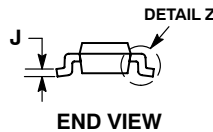
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SCALE 2:1

TSOP-5 CASE 483 ISSUE N

DATE 12 AUG 2020



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION A.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

| DIM | MILLIMETERS | |
|-----|-------------|------|
| | MIN | MAX |
| A | 2.85 | 3.15 |
| B | 1.35 | 1.65 |
| C | 0.90 | 1.10 |
| D | 0.25 | 0.50 |
| G | 0.95 BSC | |
| H | 0.01 | 0.10 |
| J | 0.10 | 0.26 |
| K | 0.20 | 0.60 |
| M | 0° | 10° |
| S | 2.50 | 3.00 |

SOLDERING FOOTPRINT*



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

GENERIC MARKING DIAGRAM*



- XXX = Specific Device Code
 A = Assembly Location
 Y = Year
 W = Work Week
 ■ = Pb-Free Package
- XXX = Specific Device Code
 M = Date Code
 ■ = Pb-Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present.

| | | |
|-------------------------|--------------------|--|
| DOCUMENT NUMBER: | 98ARB18753C | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| DESCRIPTION: | TSOP-5 | PAGE 1 OF 1 |

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MECHANICAL CASE OUTLINE

PACKAGE DIMENSIONS

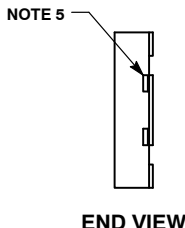
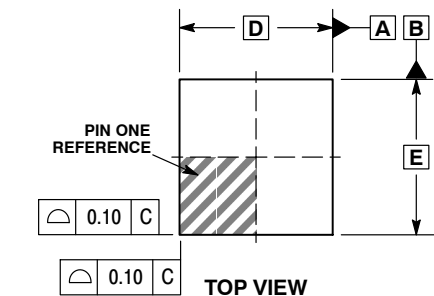
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SCALE 4:1

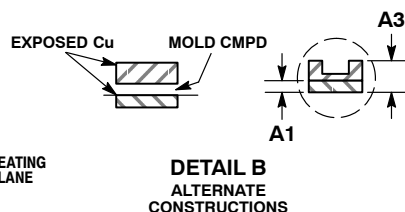
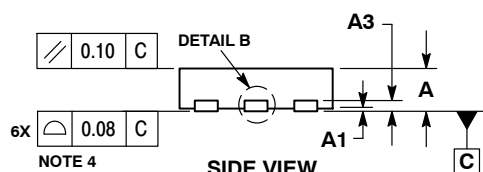
UDFN6 2x2, 0.65P
CASE 517AB
ISSUE C

DATE 10 APR 2013



- 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 0.25MM FROM THE TERMINAL TIP.
 4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
 5. TIE BARS MAY BE VISIBLE IN THIS VIEW AND ARE CONNECTED TO THE THERMAL PAD.

| DIM | MILLIMETERS | |
|-----|-------------|------|
| | MIN | MAX |
| A | 0.45 | 0.55 |
| A1 | 0.00 | 0.05 |
| A3 | 0.127 REF | |
| b | 0.25 | 0.35 |
| D | 2.00 BSC | |
| D2 | 1.50 | 1.70 |
| E | 2.00 BSC | |
| E2 | 0.80 | 1.00 |
| e | 0.65 BSC | |
| L | 0.25 | 0.35 |
| L1 | --- | 0.15 |



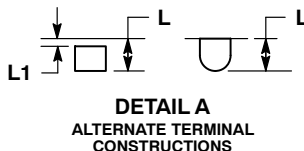
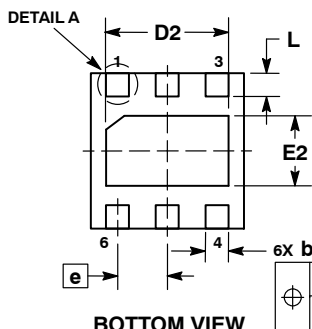
GENERIC MARKING DIAGRAM*



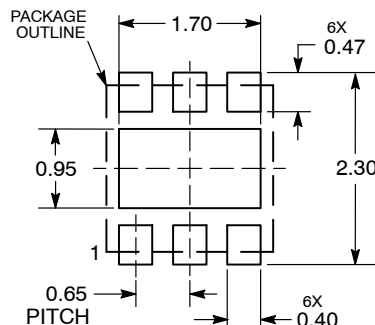
- XX = Specific Device Code
- M = Date Code
- = Pb-Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.



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.

| | | |
|-------------------------|-------------------------|--|
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| DESCRIPTION: | UDFN6 2X2, 0.65P | PAGE 1 OF 1 |

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