

# NCP434, NCP435

## 2A Ultra-Small Controlled Load Switch with Auto-Discharge Path

The NCP434 and NCP435 are a low  $R_{on}$  MOSFET controlled by external logic pin, allowing optimization of battery life, and portable device autonomy.

Indeed, due to a current consumption optimization with PMOS structure, leakage currents are eliminated by isolating connected IC's on the battery when not used.

Output discharge path is also embedded to eliminate residual voltages on the output (NCP435 only).

Available in wide input voltage range from 1.0 V to 4.0 V, and a very small 0.96 x 0.96 mm WLCSP4, 0.5 mm pitch.

### Features

- 1 V – 3.6 V Operating Range
- 29 m $\Omega$  P MOSFET at 3.3 V
- DC current up to 2 A
- Output Auto-discharge (NCP435)
- Active high EN pin
- WLCSP4 0.96 x 0.96 mm
- These are Pb-Free Devices

### Typical Applications

- Mobile Phones
- Tablets
- Digital Cameras
- GPS
- Portable Devices



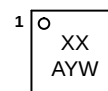
ON Semiconductor®

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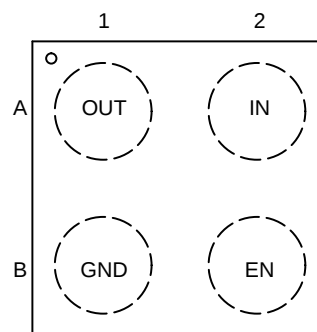
WLCSP4  
CASE 567FG

### MARKING DIAGRAM



XX = Specific Device Code  
A = Assembly Location  
Y = Year  
W = Wafer Lot

### PIN DIAGRAM



(Top View)

### ORDERING INFORMATION

See detailed ordering, marking and shipping information in the package dimensions section on page 9 of this data sheet.

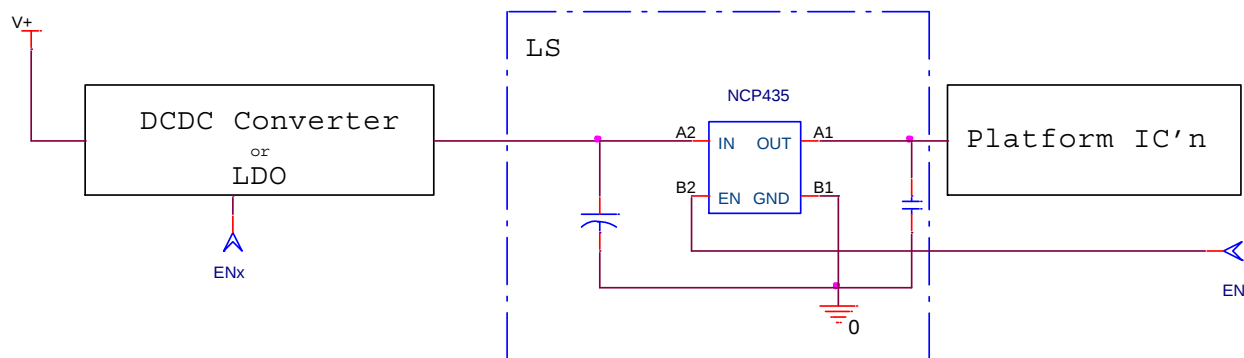


Figure 1. Typical Application Circuit

# NCP434, NCP435

## PIN FUNCTION DESCRIPTION

| Pin Name | Pin Number | Type   | Description                                                                                                                |
|----------|------------|--------|----------------------------------------------------------------------------------------------------------------------------|
| IN       | A2         | POWER  | Load-switch input voltage; connect a 1 $\mu$ F or greater ceramic capacitor from IN to GND as close as possible to the IC. |
| GND      | B1         | POWER  | Ground connection.                                                                                                         |
| EN       | B2         | INPUT  | Enable input, logic high turns on power switch.                                                                            |
| OUT      | A1         | OUTPUT | Load-switch output; connect a 1 $\mu$ F ceramic capacitor from OUT to GND as close as possible to the IC is recommended.   |

## BLOCK DIAGRAM

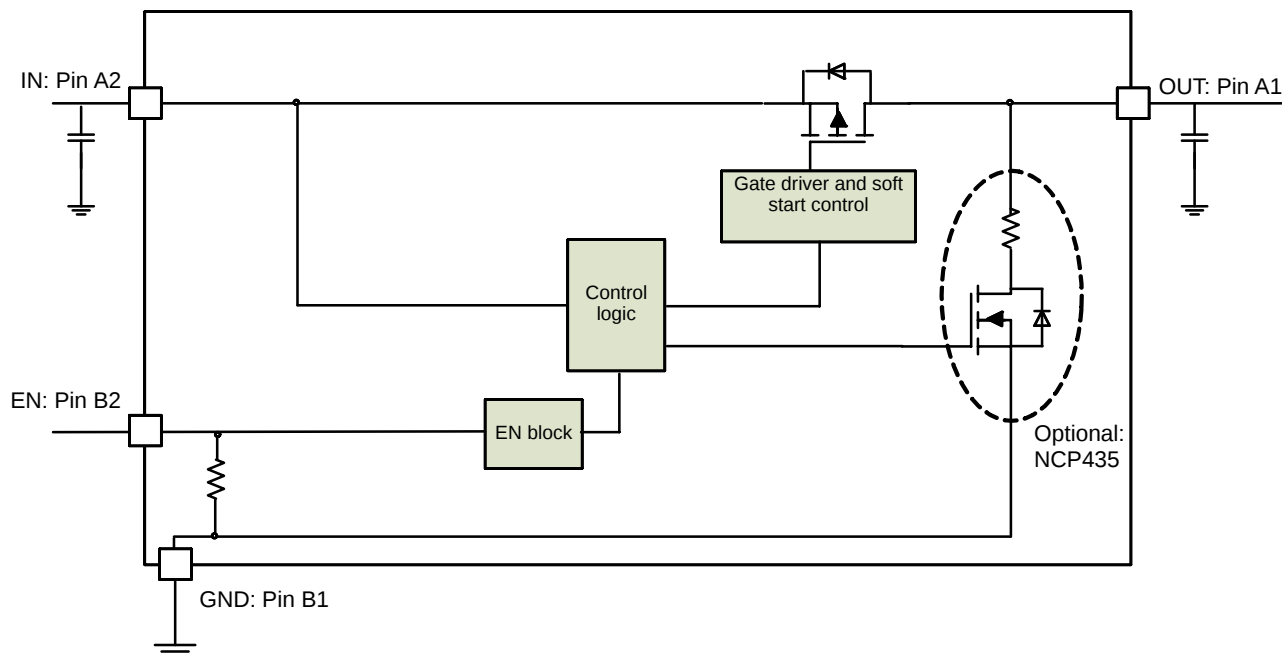


Figure 2. Block Diagram

## MAXIMUM RATINGS

| Rating                            | Symbol                    | Value        | Unit |
|-----------------------------------|---------------------------|--------------|------|
| IN, OUT, EN, Pins                 | $V_{EN}, V_{IN}, V_{OUT}$ | -0.3 to +4.0 | V    |
| From IN to OUT Pins: Input/Output | $V_{IN}, V_{OUT}$         | 0 to +4.0    | V    |
| Maximum Junction Temperature      | $T_J$                     | -40 to +125  | °C   |
| Storage Temperature Range         | $T_{STG}$                 | -40 to +150  | °C   |
| Moisture Sensitivity (Note 1)     | MSL                       | Level 1      |      |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Moisture Sensitivity Level (MSL): 1 per IPC/JEDEC standard: J-STD-020.

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## OPERATING CONDITIONS

| Symbol           | Parameter                          | Conditions             |               | Min | Typ | Max | Unit |
|------------------|------------------------------------|------------------------|---------------|-----|-----|-----|------|
| V <sub>IN</sub>  | Operational Power Supply           |                        |               | 1.0 |     | 3.6 | V    |
| V <sub>EN</sub>  | Enable Voltage                     |                        |               | 0   |     | 3.6 |      |
| T <sub>A</sub>   | Ambient Temperature Range          |                        |               | -40 | 25  | +85 | °C   |
| C <sub>IN</sub>  | Decoupling input capacitor         |                        |               | 1   |     |     | μF   |
| C <sub>OUT</sub> | Decoupling output capacitor        |                        |               | 1   |     |     | μF   |
| R <sub>θJA</sub> | Thermal Resistance Junction-to-Air | WLCSP package (Note 6) |               |     | 100 |     | °C/W |
| I <sub>OUT</sub> | Maximum DC current                 |                        |               |     |     | 2   | A    |
| P <sub>D</sub>   | Power Dissipation Rating (Note 7)  | T <sub>A</sub> ≤ 25°C  | WLCSP package |     | 0.5 |     | W    |
|                  |                                    | T <sub>A</sub> = 85°C  | WLCSP package |     | 0.2 |     | W    |

2. According to JEDEC standard JESD22-A108.

3. This device series contains ESD protection and passes the following tests:

4. Human Body Model (HBM) ±4.0 kV per JEDEC standard: JESD22-A114 for all pins.

Machine Model (MM) ±250 V per JEDEC standard: JESD22-A115 for all pins.

Charge Device Model (CDM) ±2.0 kV per JEDEC standard: JESD22-C101 for all pins.

5. Latch up Current Maximum Rating: ±100 mA per JEDEC standard: JESD78 class II.

6. The R<sub>θJA</sub> is dependent of the PCB heat dissipation and thermal via.

7. The maximum power dissipation (P<sub>D</sub>) is given by the following formula:

$$P_D = \frac{T_{JMAX} - T_A}{R_{\theta JA}}$$

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**ELECTRICAL CHARACTERISTICS** Min and Max Limits apply for  $T_A$  between  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  for  $V_{IN}$  between 1.0 V to 3.6 V (Unless otherwise noted). Typical values are referenced to  $T_A = +25^{\circ}\text{C}$  and  $V_{IN} = 3.3\text{ V}$  (Unless otherwise noted).

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|------------|-----|-----|-----|------|
|--------|-----------|------------|-----|-----|-----|------|

## POWER SWITCH

|              |                                         |                         |                                                                            |     |     |     |                  |
|--------------|-----------------------------------------|-------------------------|----------------------------------------------------------------------------|-----|-----|-----|------------------|
| $R_{DS(on)}$ | Static drain-source on-state resistance | $V_{IN} = 4\text{ V}$   | $T_A = 25^{\circ}\text{C}, I = 200\text{ mA}$ (Note 9)                     |     | 27  | 30  | $\text{m}\Omega$ |
|              |                                         | $V_{IN} = 3.3\text{ V}$ | $T_A = 25^{\circ}\text{C}, I = 200\text{ mA}$                              |     | 29  | 34  |                  |
|              |                                         | $V_{IN} = 3.3\text{ V}$ | $T_A = 85^{\circ}\text{C}$                                                 |     |     | 38  |                  |
|              |                                         | $V_{IN} = 1.8\text{ V}$ | $T_A = 25^{\circ}\text{C}, I = 200\text{ mA}$                              |     | 43  | 52  |                  |
|              |                                         | $V_{IN} = 1.2\text{ V}$ | $T_A = 25^{\circ}\text{C}, I = 200\text{ mA}$                              |     | 80  | 120 |                  |
|              |                                         | $V_{IN} = 1.1\text{ V}$ | $T_A = 25^{\circ}\text{C}, I = 100\text{ mA}$                              |     | 110 |     |                  |
| $R_{DIS}$    | Output discharge path                   | EN = low                | $V_{IN} = 3.3\text{ V}$ , NCP435 only                                      |     | 65  | 90  | $\Omega$         |
| $T_R$        | Output rise time                        | $V_{IN} = 3.3\text{ V}$ | $C_{LOAD} = 1\text{ }\mu\text{F}$ , $R_{LOAD} = 25\text{ }\Omega$ (Note 8) | 35  | 61  | 90  | $\mu\text{s}$    |
| $T_F$        | Output fall time                        | $V_{IN} = 3.3\text{ V}$ | $C_{LOAD} = 1\text{ }\mu\text{F}$ , $R_{LOAD} = 25\text{ }\Omega$ (Note 8) | 20  | 42  | 70  | $\mu\text{s}$    |
| $T_{on}$     | Gate turn on                            | $V_{IN} = 3.3\text{ V}$ | Gate turn on + Output rise time                                            | 65  | 126 | 190 | $\mu\text{s}$    |
| $T_{en}$     | Enable time                             | $V_{IN} = 3.3\text{ V}$ | From EN low to high to $V_{OUT} = 10\%$ of fully on                        | 30  | 66  | 100 | $\mu\text{s}$    |
| $V_{IH}$     | High-level input voltage                |                         |                                                                            | 0.9 |     |     | V                |
| $V_{IL}$     | Low-level input voltage                 |                         |                                                                            |     |     | 0.5 | V                |
| $R_{EN}$     | Pull down resistor                      |                         |                                                                            |     | 5.1 | 7   | $\text{M}\Omega$ |

## QUIESCENT CURRENT

|       |                     |                                              |  |      |     |               |
|-------|---------------------|----------------------------------------------|--|------|-----|---------------|
| $I_Q$ | Current consumption | $V_{IN} = 3.3\text{ V}$ , EN = low, No load  |  | 0.15 | 0.6 | $\mu\text{A}$ |
|       |                     | $V_{IN} = 3.3\text{ V}$ , EN = high, No load |  | 0.3  | 0.6 | $\mu\text{A}$ |

8. Parameters are guaranteed for  $C_{LOAD}$  and  $R_{LOAD}$  connected to the OUT pin with respect to the ground  
9. Guaranteed by design and characterization, not production tested.

## TIMINGS

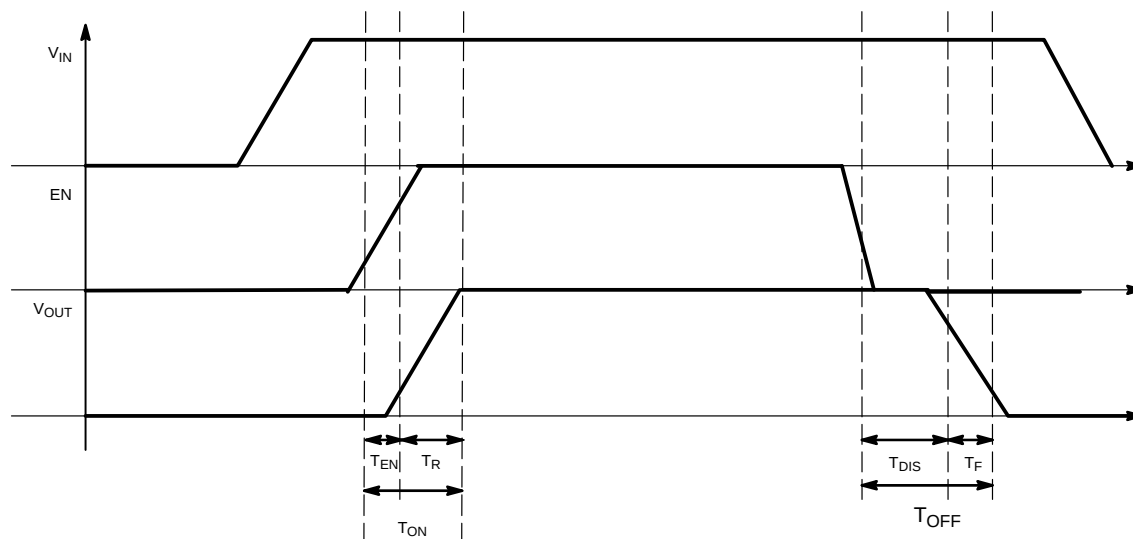


Figure 3. Enable, Rise and fall time

# NCP434, NCP435

## TYPICAL CHARACTERISTICS

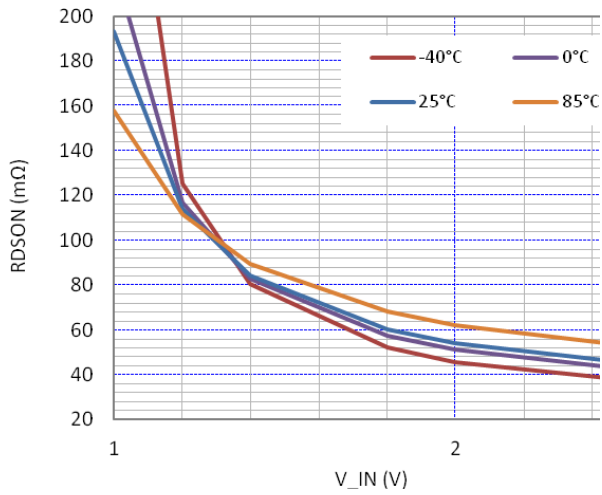


Figure 4.  $R_{DS(on)}$  (mΩ) vs.  $V_{IN}$  (V) from 1 V to 2.6 V

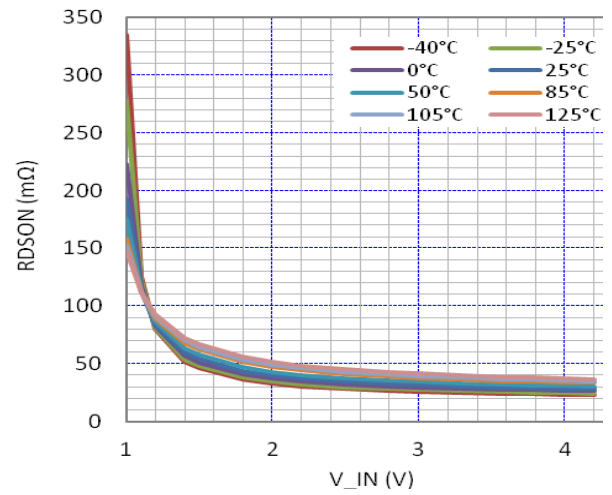


Figure 5.  $R_{DS(on)}$  (mΩ) vs.  $V_{IN}$  (V) from 1 V to 4 V

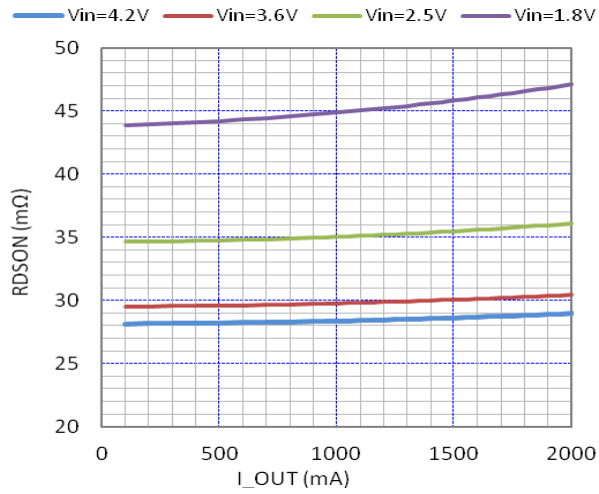


Figure 6.  $R_{DS(on)}$  (mΩ) vs.  $I_{LOAD}$  (mA)

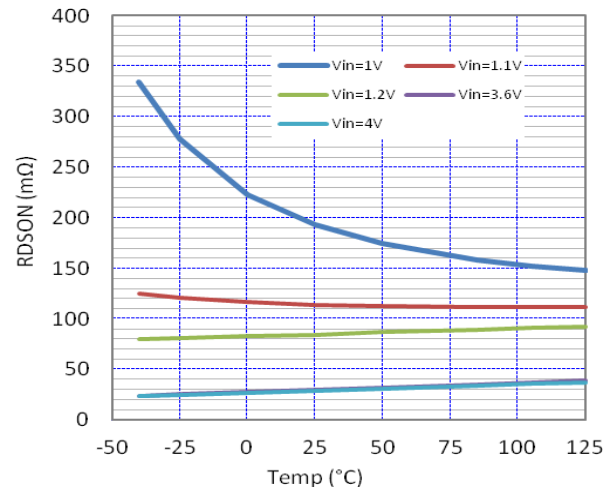
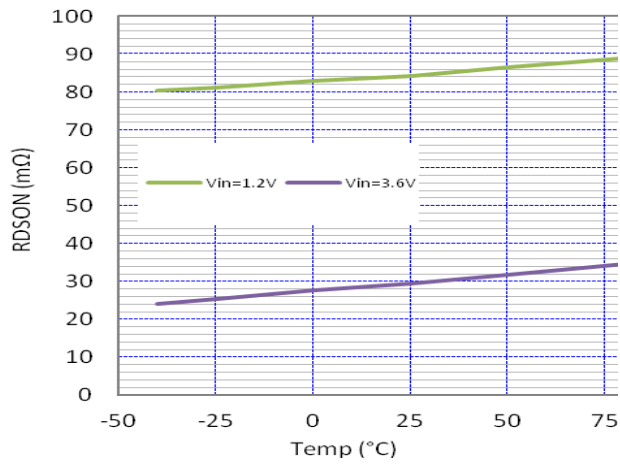
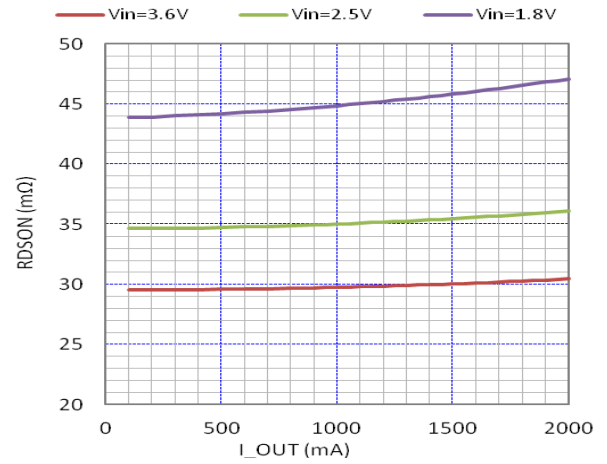


Figure 7.  $R_{DS(on)}$  (mΩ) vs. Temperature (°C)

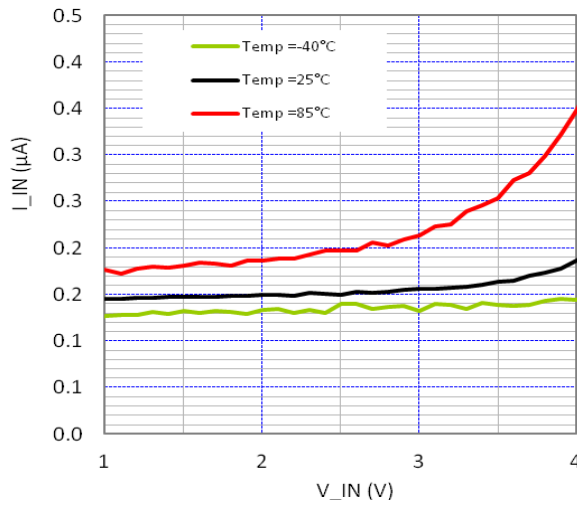
# NCP434, NCP435



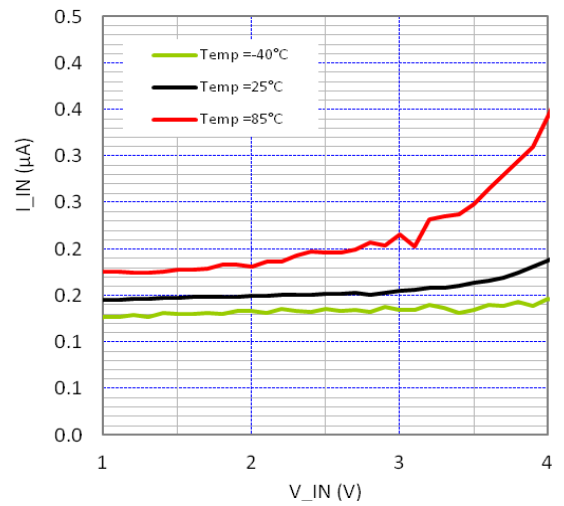
**Figure 8.  $R_{DS(on)}$  (mΩ) vs. Temperature (°C) at 1.2 V and 3.6 V**



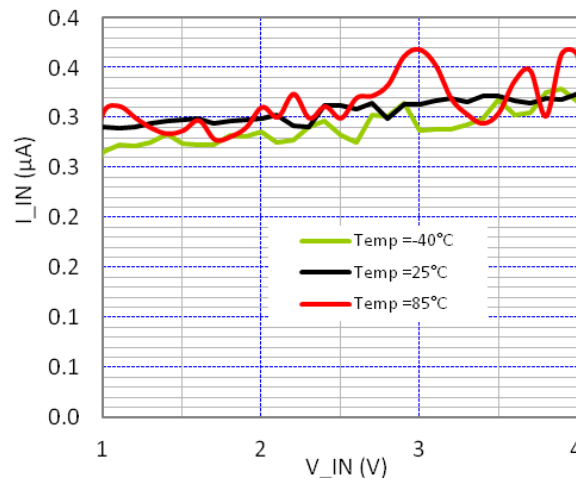
**Figure 9.  $R_{DS(on)}$  (mΩ) vs. Current (mA)**



**Figure 10. Standby Current (μA) versus  $V_{IN}$  (V), No Load**



**Figure 11. Standby Current (μA) versus  $V_{IN}$  (V),  $V_{OUT}$  Short to GND**



**Figure 12. Quiescent Current (μA) versus  $V_{IN}$  (V), No Load**

# NCP434, NCP435

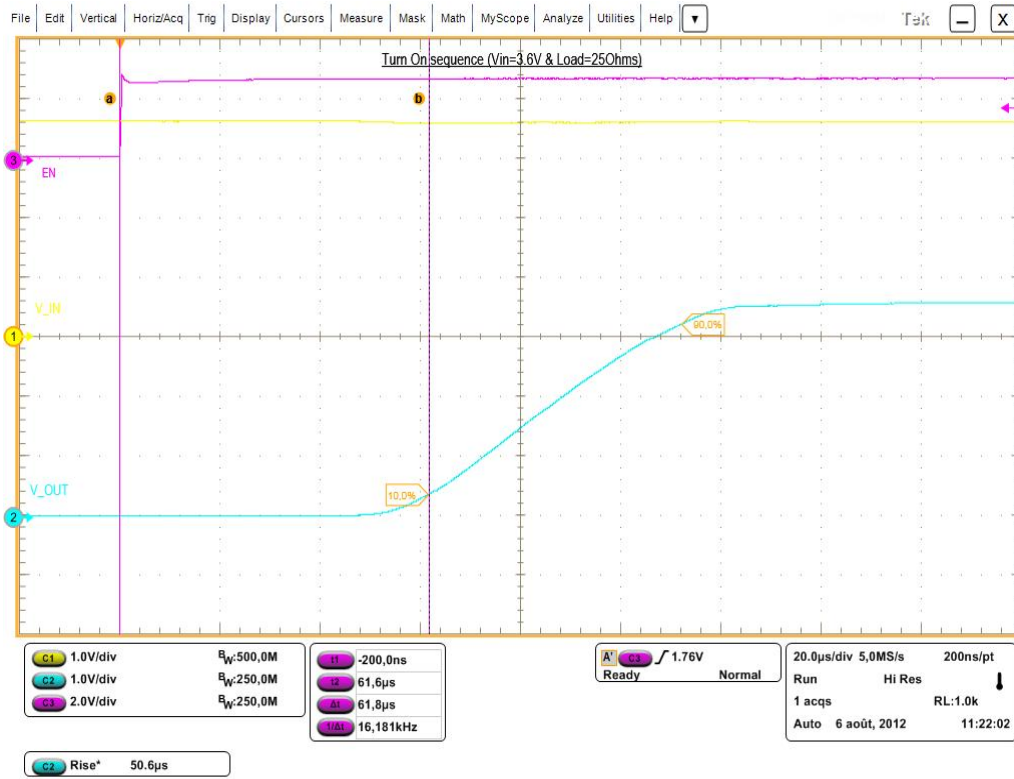


Figure 13. Enable Time, Rise Time, and Ton Time

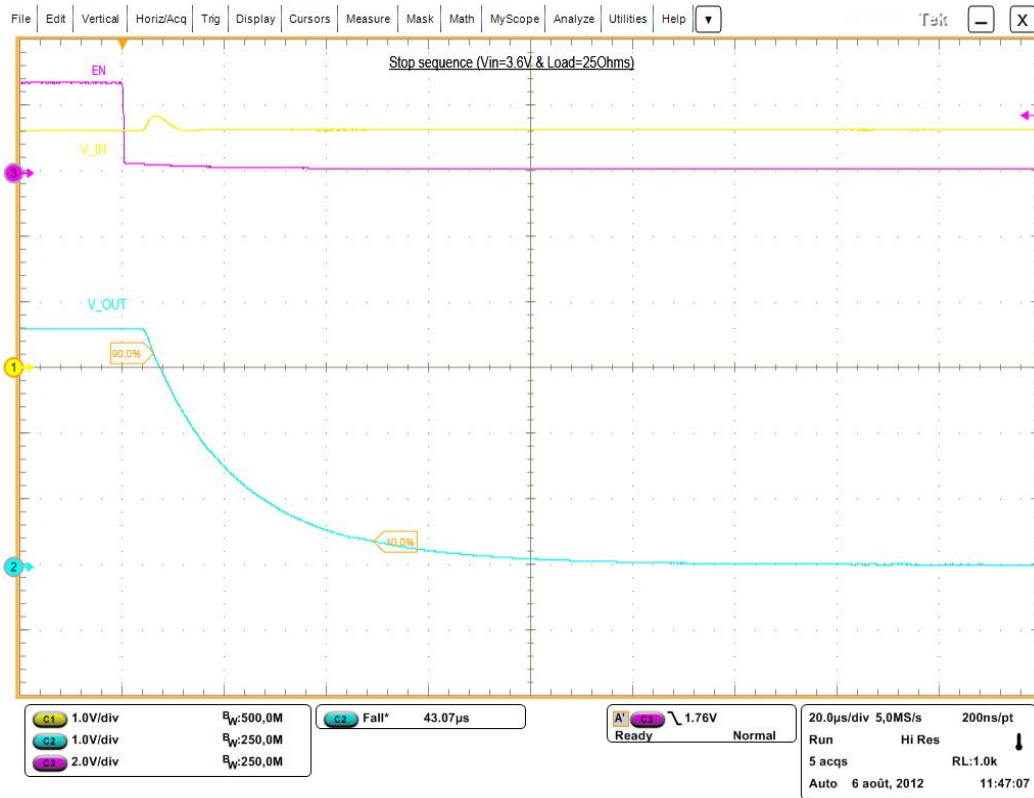


Figure 14. Disable Time, Fall Time and Toff Time

## FUNCTIONAL DESCRIPTION

### Overview

The NCP434 – NCP435 are high side P channel MOSFET power distribution switch designed to isolate ICs connected on the battery in order to save energy. The part can be turned on, with a range of battery from 1.0 V to 4 V.

### Enable Input

Enable pin is an active high. The path is opened when EN pin is tied low (disable), forcing P MOS switch off.

The IN/OUT path is activated with a minimum of  $V_{IN}$  of 1.0 V and EN forced to high level.

### Auto Discharge (NCP435 Only)

NMOS FET is placed between the output pin and GND, in order to discharge the application capacitor connected on OUT pin.

The auto-discharge is activated when EN pin is set to low level (disable state).

The discharge path ( Pull down NMOS) stays activated as long as EN pin is set at low level and  $V_{IN} > 1.0$  V.

In order to limit the current across the internal discharge NMOSFET, the typical value is set at 65  $\Omega$ .

### $C_{IN}$ and $C_{OUT}$ Capacitors

IN and OUT, 1  $\mu$ F, at least, capacitors must be placed as close as possible the part for stability improvement.

## APPLICATION INFORMATION

### Power Dissipation

Main contributor in term of junction temperature is the power dissipation of the power MOSFET. Assuming this, the power dissipation and the junction temperature in normal mode can be calculated with the following equations:

$$P_D = R_{DS(on)} \times (I_{OUT})^2$$

$P_D$  = Power dissipation (W)  
 $R_{DS(on)}$  = Power MOSFET on resistance ( $\Omega$ )  
 $I_{OUT}$  = Output current (A)

$$T_J = R_D \times R_{\theta JA} + T_A$$

$T_J$  = Junction temperature ( $^{\circ}$ C)  
 $R_{\theta JA}$  = Package thermal resistance ( $^{\circ}$ C/W)  
 $T_A$  = Ambient temperature ( $^{\circ}$ C)

### PCB Recommendations

The NCP434 – NCP435 integrate an up to 2 A rated PMOS FET, and the PCB design rules must be respected to properly evacuate the heat out of the silicon. By increasing PCB area, especially around IN and OUT pins, the  $R_{\theta JA}$  of the package can be decreased, allowing higher power dissipation.

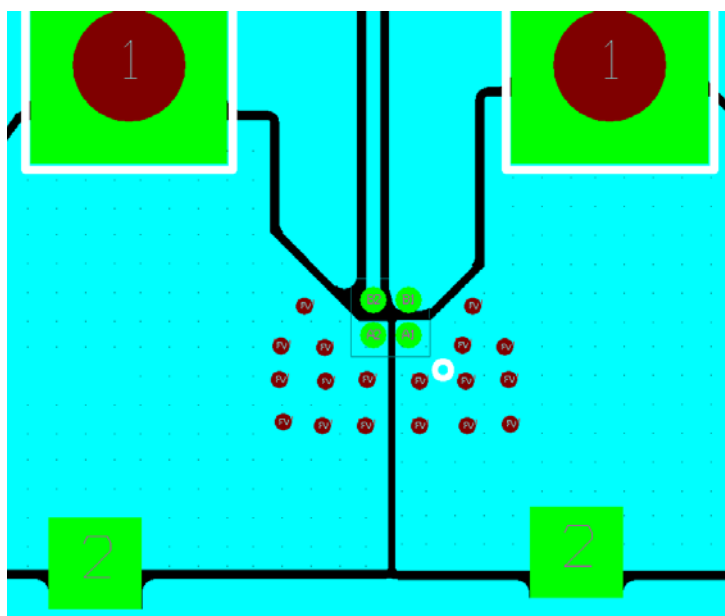


Figure 15. Routing Example 1 oz, 2 Layers, 100°C/W

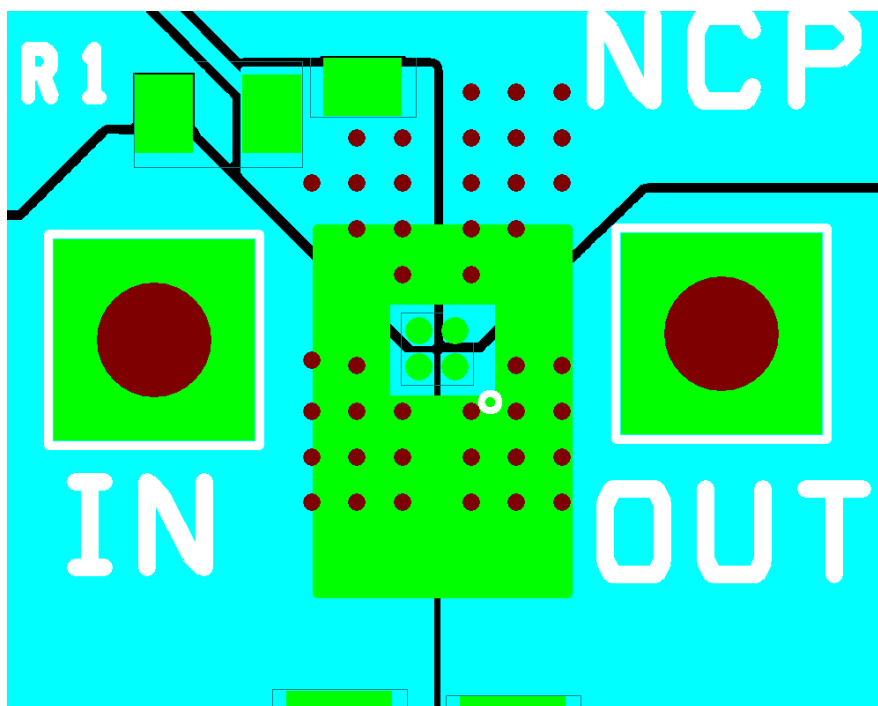


Figure 16. Routing Example 2 oz, 4 Layers, 60°C/W

**Example of Application Definition**

$$T_J - T_A = R_{\theta JA} \times P_D = R_{\theta JA} \times R_{DS(on)} \times I^2$$

$T_J$ : Junction Temperature.

$T_A$ : Ambient Temperature.

$R_{\theta}$  = Thermal resistance between IC and air, through PCB.

$R_{DS(on)}$ : intrinsic resistance of the IC MOSFET.

$I$ : load DC current.

Taking into account of  $R_{\theta}$  obtain with:

- 1 oz, 2 layers: 100°C/W.

At 2 A, 25°C ambient temperature,  $R_{DS(on)}$  44 mΩ @  $V_{IN}$  1.8 V, the junction temperature will be:

$$T_J = R_{\theta JA} \times P_D = 25 + (0.044 \times 2^2) \times 100 = 46^\circ\text{C}$$

Taking into account of  $R_{\theta}$  obtain with:

- 2 oz, 4 layers: 60°C/W.

At 2 A, 25°C ambient temperature,  $R_{DS(on)}$  44 mΩ @  $V_{IN}$  1.8 V, the junction temperature will be:

$$T_J = T_A + R_{\theta} \times P_D = 25 + (0.044 \times 2^2) \times 60 = 35.5^\circ\text{C}$$

**ORDERING INFORMATION**

| Device      | Marking | Package                           | Shipping <sup>†</sup> |
|-------------|---------|-----------------------------------|-----------------------|
| NCP434FCT2G | AJ      | WLCSP 0.96 x 0.96 mm<br>(Pb-Free) | 3000 / Tape & Reel    |
| NCP435FCT2G | AH      | WLCSP 0.96 x 0.96 mm<br>(Pb-Free) | 3000 / Tape & Reel    |

<sup>†</sup>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.

# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

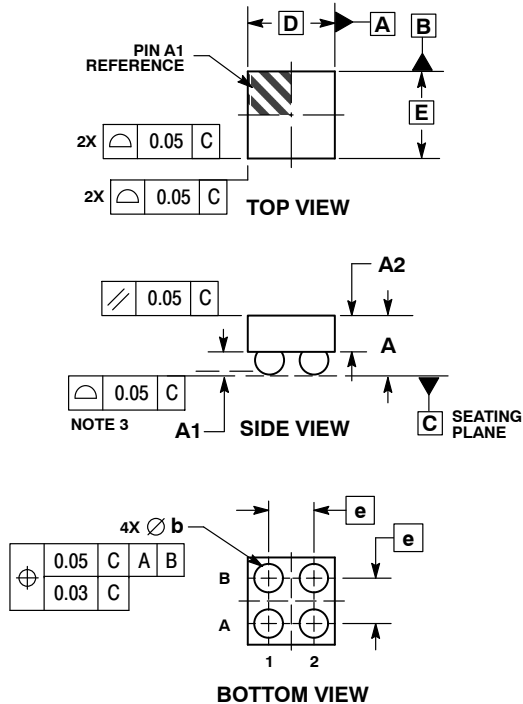
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SCALE 4:1

WLCSP4, 0.96x0.96  
CASE 567FG  
ISSUE O

DATE 17 APR 2012

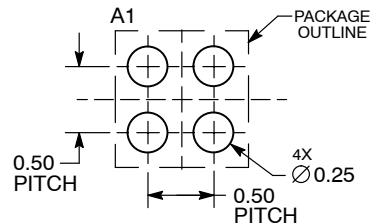


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO SPHERICAL CROWNS OF SOLDER BALLS.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 0.54        | 0.63 |
| A1  | 0.22        | 0.28 |
| A2  | 0.33        | REF  |
| b   | 0.29        | 0.34 |
| D   | 0.96        | BSC  |
| E   | 0.96        | BSC  |
| e   | 0.50        | BSC  |

### 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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| <b>DESCRIPTION:</b>     | <b>WLCSP4, 0.96X0.96</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                               |

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