

# NCP436, NCP437

## 3A Ultra-Small Controlled Load Switch with Auto-Discharge Path

The NCP436 and NCP437 are very 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 on the battery when not used.

Output discharge path is also embedded to eliminate residual voltages on the output rail for the NCP437 part only.

Proposed in a wide input voltage range from 1.0 V to 3.6 V, in a small 1 x 1.5 mm WLCSP6, pitch 0.5 mm.

### Features

- 1.0 V – 3.6 V Operating Range
- 20 m $\Omega$  P MOSFET at 3.6 V
- DC Current Up to 3 A
- Output Auto-discharge
- Active High EN Pin
- WLCSP6 1 x 1.5 mm
- These are Pb-Free Devices

### Typical Applications

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



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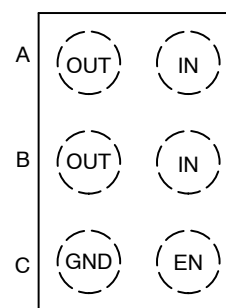
WLCSP6  
CASE 567FH

### MARKING DIAGRAM



XX = Specific Device Code

### PIN DIAGRAM



(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 6 of this data sheet.

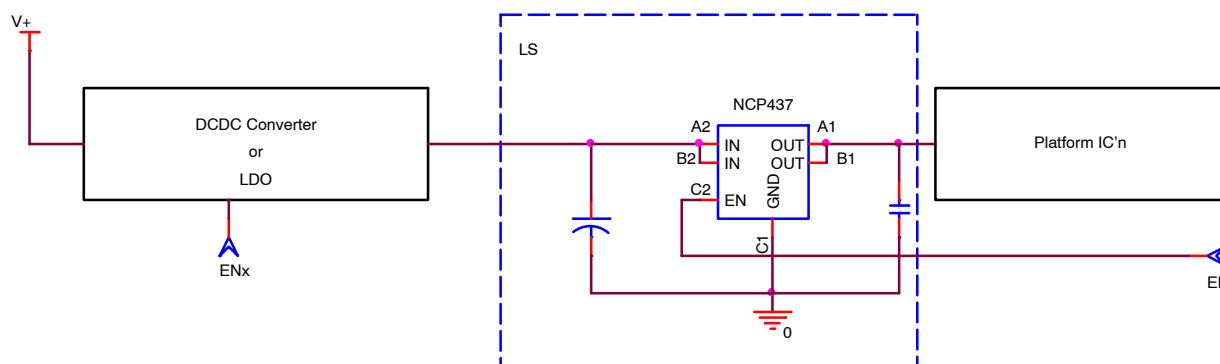


Figure 1. Typical Application Circuit

# NCP436, NCP437

## PIN FUNCTION DESCRIPTION

Pin Name	Pin Number	Type	Description
IN	A2, B2	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	C1	POWER	Ground connection.
EN	C2	INPUT	Enable input, logic high turns on power switch.
OUT	A1, B1	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

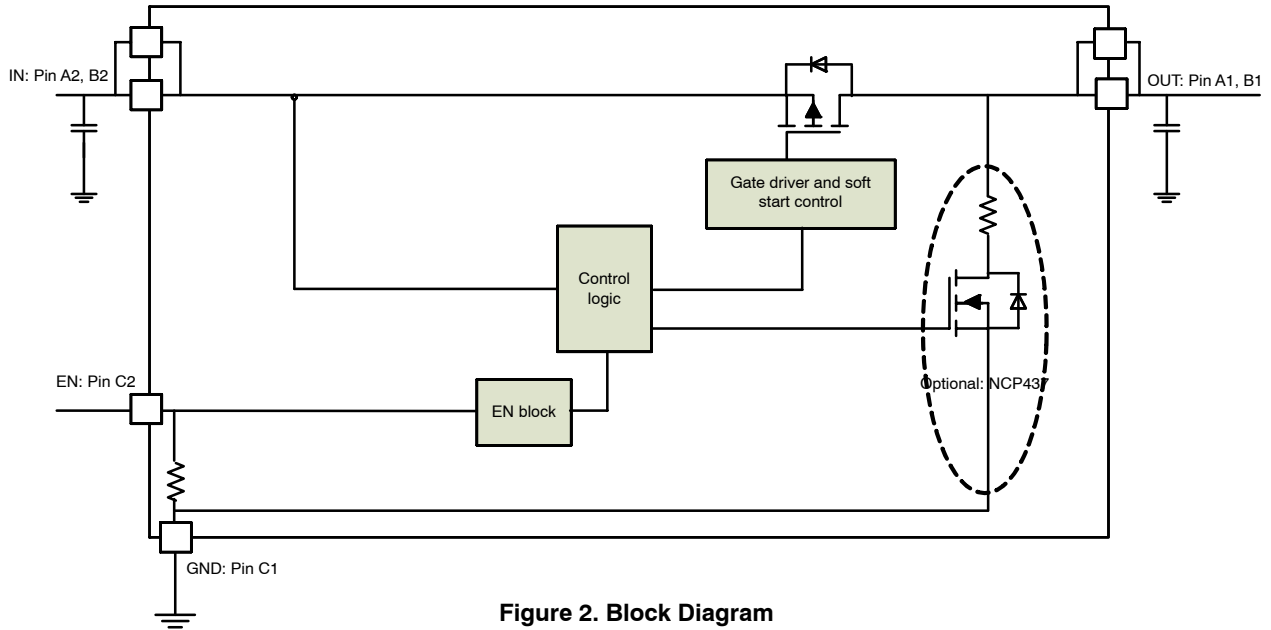


Figure 2. Block Diagram

# NCP436, NCP437

## MAXIMUM RATINGS

Symbol	Rating	Value	Unit
$V_{EN}, V_{IN}, V_{OUT}$	IN, OUT, EN, Pins: (Note 1)	-0.3 to + 4	V
$V_{IN}, V_{OUT}$	From IN to OUT Pins: Input/Output (Note 1)	0 to + 4	V
$T_J$	Maximum Junction Temperature	-40 to + 125	°C
ESD HBM	Human Body Model (HBM) ESD Rating are (Notes 2 and 3)	8000	V
ESD MM	Machine Model (MM) ESD Rating are (Notes 2 and 3)	250	V
ESD CDM	Charge Device Model (CDM) ESD Rating are (Notes 2 and 3)	2000	V
LU	Latch-up Protection (Note ) - Pins IN, OUT, EN	100	mA
$T_{STG}$	Storage Temperature Range	-40 to + 150	°C
MSL	Moisture Sensitivity (Note 2)	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. According to JEDEC standard JESD22-A108.
2. Moisture Sensitivity Level (MSL): 1 per IPC/JEDEC standard: J-STD-020.
3. This device series contains ESD protection and passes the following tests  
Human Body Model (HBM) ±8.0 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.
4. Latch-up Current Maximum Rating: ±100 mA per JEDEC standard: JESD78 Class II.

## OPERATING CONDITIONS

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IN}$	Operational Power Supply		1.0		3.6	V
$V_{EN}$	Enable Voltage		0		3.6	
$T_A$	Ambient Temperature Range		-40	25	+85	°C
$T_J$	Junction Temperature Range		-40	25	+125	°C
$C_{IN}$	Decoupling input capacitor		1			μF
$C_{OUT}$	Decoupling output capacitor		1			μF
$R_{\theta JA}$	Thermal Resistance Junction to Air	WLCSP package (Note 5)		100		°C/W
$I_{OUT}$	Maximum DC current				3	A
$P_D$	Power Dissipation Rating (Note 6)	$T_A \leq 25^\circ\text{C}$	WLCSP package		0.66	W
		$T_A = 85^\circ\text{C}$	WLCSP package		0.26	W

5. The  $R_{\theta JA}$  is dependent of the PCB heat dissipation and thermal via.
6. The maximum power dissipation ( $P_D$ ) is given by the following formula:

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

# NCP436, NCP437

**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	
<b>POWER SWITCH</b>							
$R_{DS(on)}$	Static drain-source on-state resistance	$V_{IN} = 3.6\text{ V}$	$I = 200\text{ mA}, 25^{\circ}\text{C}$		15	26	m $\Omega$
			$I = 200\text{ mA}, T_A = 85^{\circ}\text{C}$			28	
			$T_J = 125^{\circ}\text{C}$			29	
		$V_{IN} = 2.5\text{ V}$	$I = 200\text{ mA}, 25^{\circ}\text{C}$		18	30	
			$I = 200\text{ mA}, T_A = 85^{\circ}\text{C}$			32	
			$T_J = 125^{\circ}\text{C}$			35	
		$V_{IN} = 1.8\text{ V}$	$I = 200\text{ mA}, 25^{\circ}\text{C}$		23	40	
			$I = 200\text{ mA}, \text{Full } T_a$			42	
			$T_J = 125^{\circ}\text{C}$			44	
		$V_{IN} = 1.2\text{ V}$	$I = 200\text{ mA}, 25^{\circ}\text{C}$		45	80	
			$I = 200\text{ mA}, \text{Full } T_a$			84	
			$T_J = 125^{\circ}\text{C}$			85	
$V_{IN} = 1.1\text{ V}$	$I = 200\text{ mA}, 25^{\circ}\text{C}$		62				
$R_{dis}$	Output discharge path	$V_{IN} = 3.3\text{ V}$	$EN = \text{low}$	50	65	90	$\Omega$
$V_{IH}$	High-level input voltage			1.1			V
$V_{IL}$	Low-level input voltage					0.5	

### QUIESCENT CURRENT

$I_{std}$	Standby current	$V_{IN} = 3.3\text{ V}$	$EN = \text{low}, \text{No load}$		0.01	0.6	$\mu\text{A}$
$I_q$	Quiescent current	$V_{IN} = 3.3\text{ V}$	$EN = \text{high}, \text{No load}$		0.2	0.6	

### TIMINGS

$T_{EN}$	Enable time	$V_{IN} = 3.6\text{ V}$ (Note 8)	$R_L = 25\ \Omega, C_{OUT} = 1\ \mu\text{F}$	20	39	55	$\mu\text{s}$
$T_R$	Output rise time		$R_L = 25\ \Omega, C_{OUT} = 1\ \mu\text{F}$	10	25	40	
$T_{ON}$	ON time ( $T_{EN} + T_R$ )		$R_L = 25\ \Omega, C_{OUT} = 1\ \mu\text{F}$	30	64	95	
$T_{DIS}$	Disable time		$R_L = 25\ \Omega, C_{OUT} = 1\ \mu\text{F}$		20		
$T_F$	Output fall time		NCP437. $R_L = 25\ \Omega,$ $C_{OUT} = 1\ \mu\text{F}$	20	55	80	

7. Guaranteed by design and characterization

8. Parameters are guaranteed for  $C_{LOAD}$  and  $R_{LOAD}$  connected to the OUT pin with respect to the ground

# NCP436, NCP437

## TIMINGS

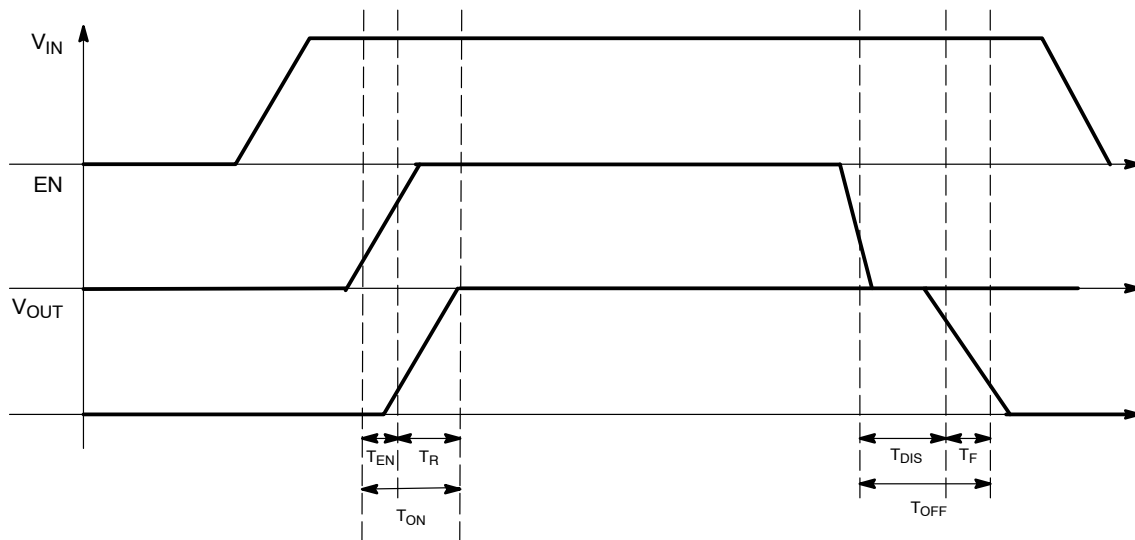


Figure 3. Enable, Rise and Fall Time

## FUNCTIONAL DESCRIPTION

### Overview

The NCP437 is a 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 wide range of battery from 1.0 V to 3.6 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 1.2 V and EN forced to high level.

### Auto Discharge

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  $V_{IN} > 1.2$  V.

In order to limit the current across the internal discharge N-MOSFET, 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 to for stability improvement.

# NCP436, NCP437

## 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)

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

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

### PCB Recommendations

The NCP437 integrates an up to 3 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.

Routing example: 2 oz, 4 layers with vias across two internal inners.

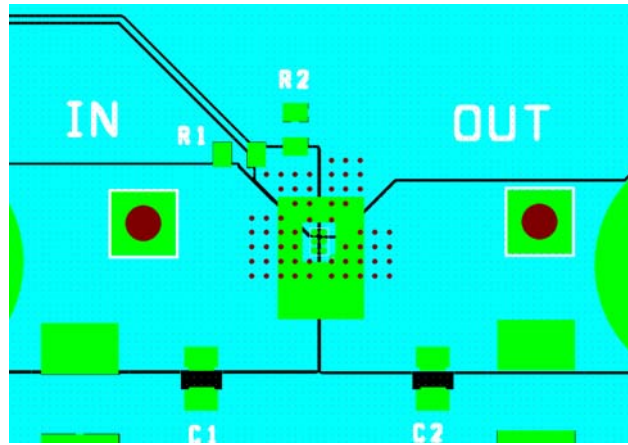


Figure 4.

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 $^{\circ}C/W$ .

At 3 A, 25 $^{\circ}C$  ambient temperature,  $R_{DS(on)}$  20 m $\Omega$  @  $V_{IN}$  5 V, the junction temperature will be:

$$T_J = R_{\theta JA} \times P_D = 25 + (0.02 \times 3^2) \times 100 = 43^{\circ}C$$

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

- 2 oz, 4 layers: 60 $^{\circ}C/W$ .

At 3 A, 65 $^{\circ}C$  ambient temperature,  $R_{DS(on)}$  24 m $\Omega$  @  $V_{IN}$  5 V, the junction temperature will be:

$$T_J = T_A + R_{\theta} \times P_D = 65 + (0.024 \times 3^2) \times 60 = 78^{\circ}C$$

### ORDERING INFORMATION

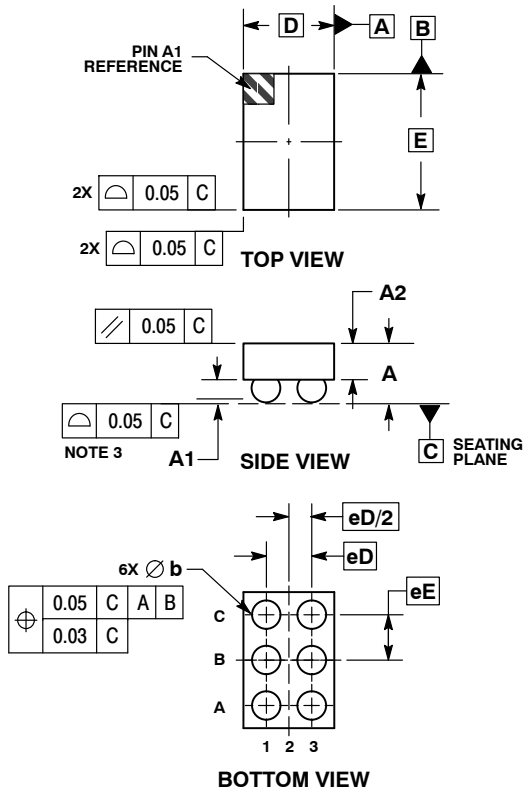
Device	Marking	Option	Package	Shipping†
NCP437FCT2G	AR	Auto discharge	WLCSP 1 x 1.5 mm (Pb-Free)	3000 / Tape & Reel
NCP436FCT2G	AQ	Without Auto discharge	WLCSP 1 x 1.5 mm (Pb-Free)	3000 / Tape & Reel

†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.

# NCP436, NCP437

## PACKAGE DIMENSIONS

WLCSP6, 1.00x1.50  
CASE 567FH  
ISSUE O

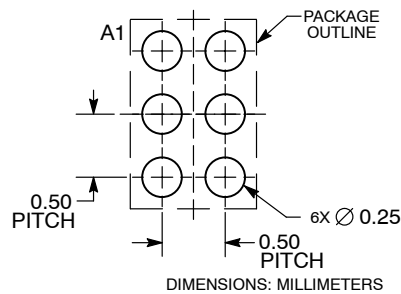


**NOTES:**

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	1.00 BSC	
E	1.50 BSC	
e	0.50 BSC	

**RECOMMENDED 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.

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