

# NCP338

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

The NCP338 is very low Ron 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.

Proposed in a wide input voltage range from 1.0 V to 3.6 V, in a small 0.8 x 1.2 mm WLCSP6, pitch 0.4 mm.

### Features

- 1.0 V – 3.6 V Operating Range
- 16 mΩ P MOSFET at 3.6 V
- DC Current Up to 2 A
- Output Auto-discharge
- Active High EN Pin
- WLCSP6 0.8 x 1.2 mm
- ESD Ratings: 6 kV HBM, 250 V MM
- This is a Pb-Free Device

### Typical Applications

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



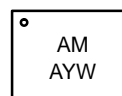
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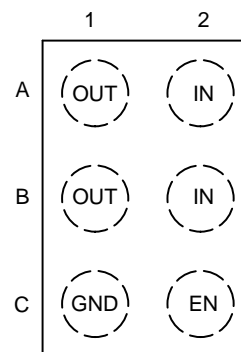
WLCSP6  
CASE 567FY

### MARKING DIAGRAM



AM = Specific Device Code  
A = Assembly Location  
Y = Year  
W = Work Week

### PIN DIAGRAM



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

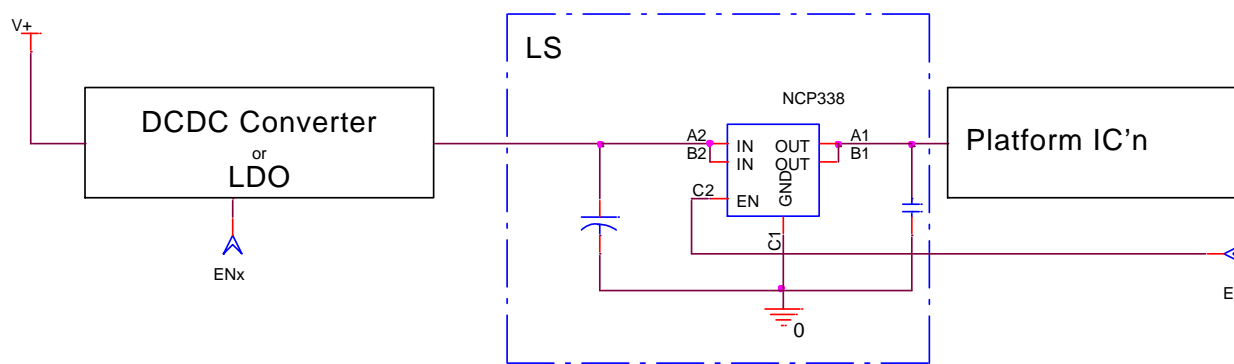


Figure 1. Typical Application Circuit

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## 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

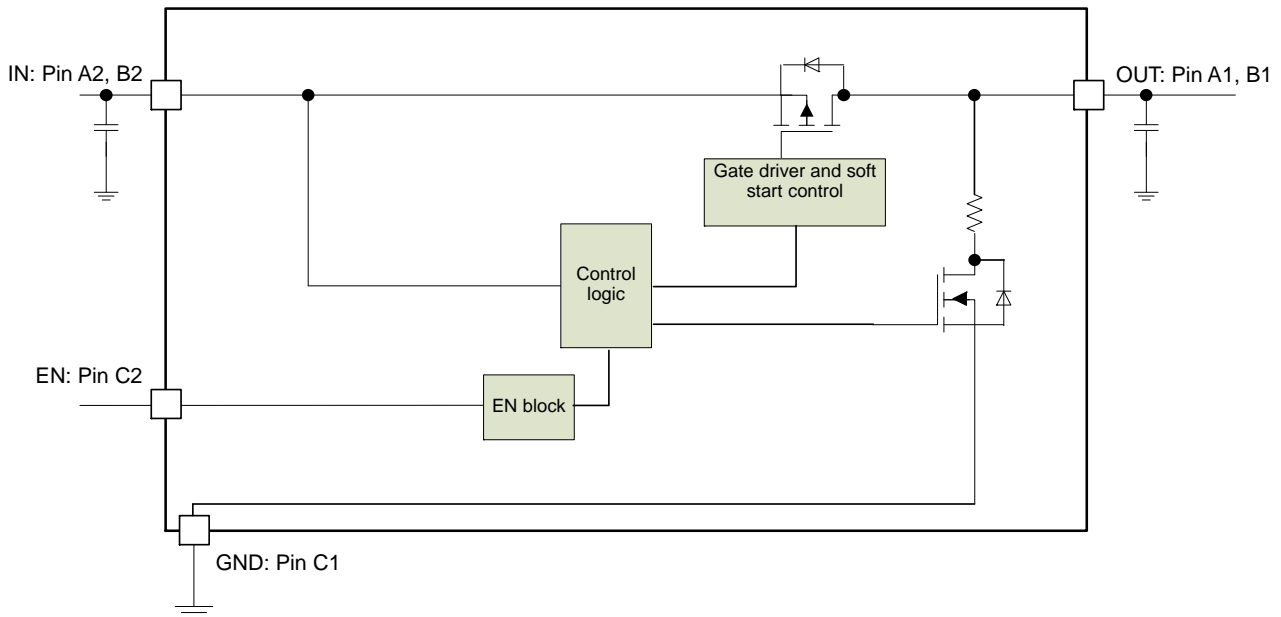


Figure 2. Block Diagram

## 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	$^{\circ}$ C
Storage Temperature Range	$T_{STG}$	-40 to + 150	$^{\circ}$ C
Human Body Model (HBM) ESD Rating are (Note 1 and 2)	ESD HBM	6000	V
Machine Model (MM) ESD Rating are (Note 1 and 2)	ESD MM	250	V
Moisture Sensitivity (Note 3)	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. According to JEDEC standard JESD22-A108.
2. This device series contains ESD protection and passes the following tests:  
Human Body Model (HBM)  $\pm 2.0$  kV per JEDEC standard: JESD22-A114 for all pins.  
Machine Model (MM)  $\pm 200$  V per JEDEC standard: JESD22-A115 for all pins.
3. 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
T <sub>J</sub>	Junction Temperature Range			-40	25	+125	°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 5)			100		°C/W
I <sub>OUT</sub>	Maximum DC current					2	A
P <sub>D</sub>	Power Dissipation Rating (Note 6)	T <sub>A</sub> ≤ 25°C	WLCSP package			1	W
		T <sub>A</sub> = 85°C	WLCSP package			0.4	W

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

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

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

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

**ELECTRICAL CHARACTERISTICS** Min and Max Limits apply for T<sub>A</sub> between -40°C to +85°C for V<sub>IN</sub> between 1.0 V to 3.6 V (Unless otherwise noted). Typical values are referenced to T<sub>A</sub> = +25°C and V<sub>IN</sub> = 3.6 V (Unless otherwise noted).

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
<b>POWER SWITCH</b>							
R <sub>DS(on)</sub>	Static drain–source on–state resistance at –200 mA	V <sub>IN</sub> = 3.6 V	T <sub>A</sub> = 25°C		16	27	mΩ
			-40°C < T <sub>A</sub> < 85°C			30	
		V <sub>IN</sub> = 2.5 V	T <sub>A</sub> = 25°C		21	36	
			-40°C < T <sub>A</sub> < 85°C			40	
		V <sub>IN</sub> = 1.8 V	T <sub>A</sub> = 25°C		27	40	
			-40°C < T <sub>A</sub> < 85°C			45	
		V <sub>IN</sub> = 1.2 V	T <sub>A</sub> = 25°C		52	87	
		-40°C < T <sub>A</sub> < 85°C			99		
	Static drain–source on–state resistance at –100 mA	V <sub>IN</sub> = 1.1 V	T <sub>A</sub> = 25°C		67		
R <sub>dis</sub>	Output discharge path	EN = low	V <sub>in</sub> = 3.3 V		65	90	Ω
V <sub>IH</sub>	High–level input voltage	V <sub>in</sub> = 1.8 V		0.95			V
V <sub>IL</sub>	Low–level input voltage					0.5	V
I <sub>EN</sub>	EN leakage current				20		nA

## CURRENT CONSUMPTION

I <sub>std</sub>	Standby current	V <sub>OUT</sub> = open, EN = low, V <sub>IN</sub> = 3.6 V		20	300	nA
		V <sub>OUT</sub> = open, EN = low, V <sub>IN</sub> = 1.8 V		4		
I <sub>q</sub>	Quiescent current	V <sub>OUT</sub> = open, EN = high, V <sub>IN</sub> = 3.6 V		200	600	nA
		V <sub>OUT</sub> = open, EN = high, V <sub>IN</sub> = 1.8 V		80	300	

7. Parameters are guaranteed for C<sub>LOAD</sub> and R<sub>LOAD</sub> connected to the OUT pin with respect to the ground.

8. Guaranteed by design and characterization.

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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  $V_{IN} = 3.6\text{ V}$  (Unless otherwise noted).

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
<b>TIMINGS</b>							
$T_{ON}$	Turn on time	$V_{IN} = 1.2\text{ V}$	$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		40		$\mu\text{s}$
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		40		
$T_R$	$V_{OUT}$ rise time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		20		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		25		
$T_{OFF}$	Turn off time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		10		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		10		
$T_{FALL}$	$V_{OUT}$ fall time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		20		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		200		

<b>TIMINGS</b>							
$T_{ON}$	Turn on time	$V_{IN} = 1.8\text{ V}$	$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		40		$\mu\text{s}$
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		40		
$T_R$	$V_{OUT}$ rise time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		30		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		35		
$T_{OFF}$	Turn off time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		10		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		10		
$T_{FALL}$	$V_{OUT}$ fall time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		15		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		150		

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

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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  $V_{IN} = 3.6\text{ V}$  (Unless otherwise noted).

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
<b>TIMINGS</b>							
$T_{ON}$	Turn on time	$V_{IN} = 3.6\text{ V}$	$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		30		$\mu\text{s}$
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)	0	32	80	
$T_R$	$V_{OUT}$ rise time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		20		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)	0	20	50	
$T_{OFF}$	Turn off time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		10		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)	0	10	40	
$T_{FALL}$	$V_{OUT}$ fall time		$C_{LOAD} = 0.1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)		10		
			$C_{LOAD} = 1\ \mu\text{F}$ , $R_{LOAD} = 500\ \Omega$ (Note 7)	0	100	300	

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

## TIMINGS

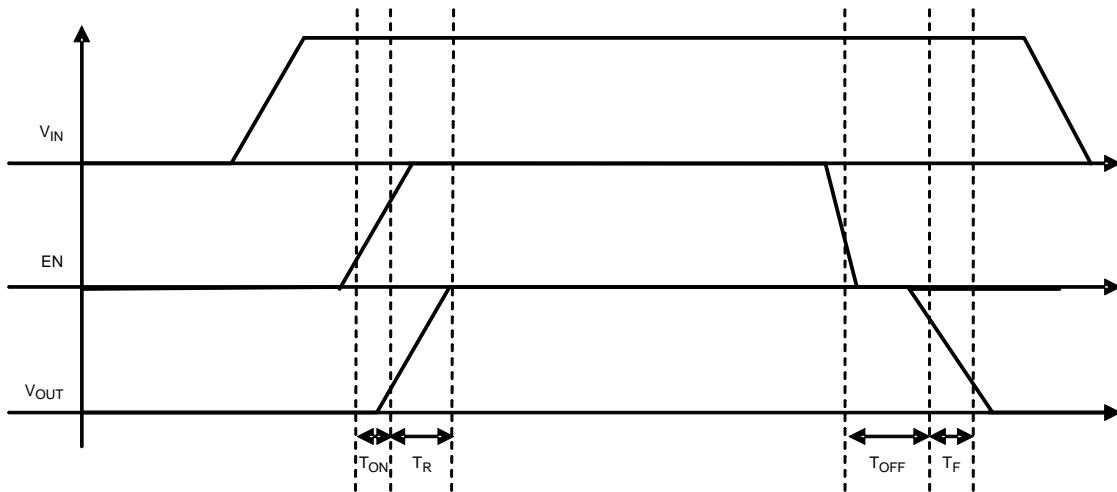


Figure 3. Enable, Rise and Fall Time

TYPICAL CHARACTERISTICS

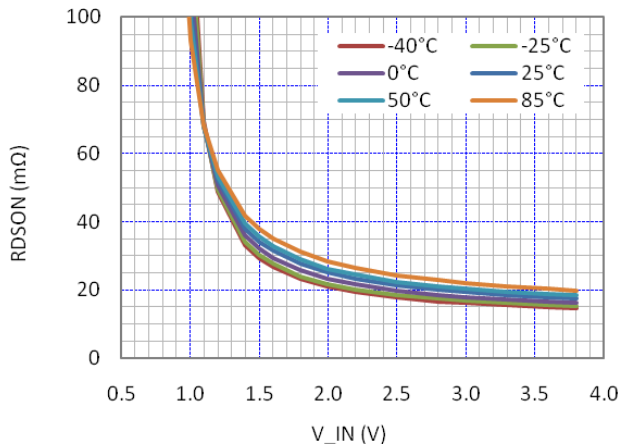


Figure 4.  $R_{DS(on)}$  (mΩ) vs.  $V_{in}$  (V) in Temperature

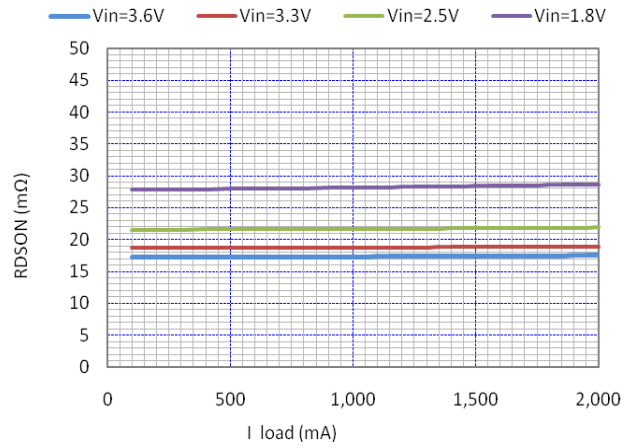


Figure 5.  $R_{DS(on)}$  (mΩ) vs.  $I_{load}$  at Different Input Voltage

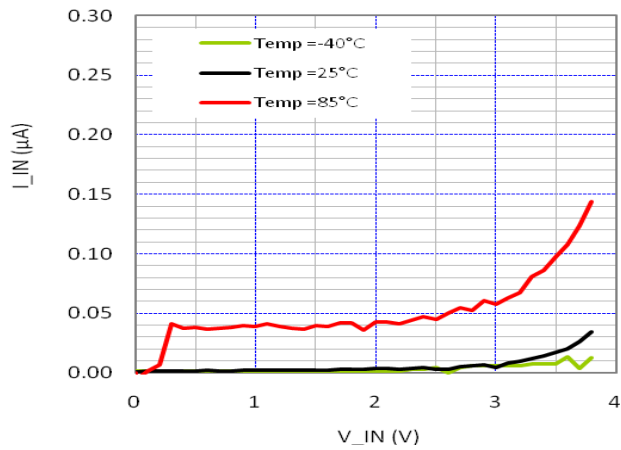


Figure 6. Standby Current ( $\mu A$ ) vs.  $V_{in}$  (V)

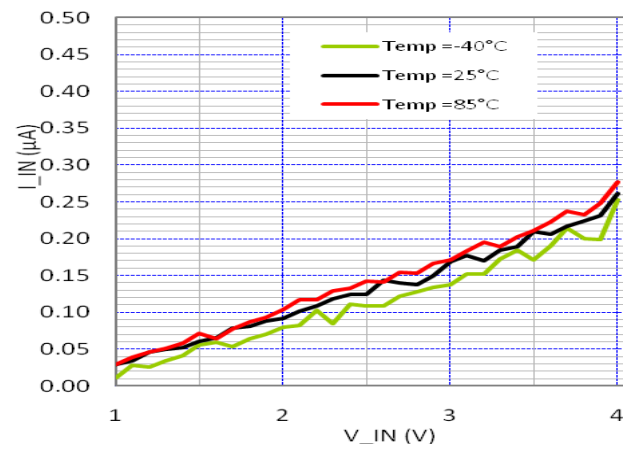


Figure 7. Quiescent Current ( $\mu A$ ) vs.  $V_{in}$  (V)

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## FUNCTIONAL DESCRIPTION

### Overview

The NCP338 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

N-MOSFET 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 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.

## 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)

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

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

### PCB Recommendations

The NCP338 integrates 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.

## ORDERING INFORMATION

Device	Marking	Autodischarge	Package	Shipping†
NCP338FCCT2G	AM	Yes	WLCSP 0.8 x 1.2 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.

# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

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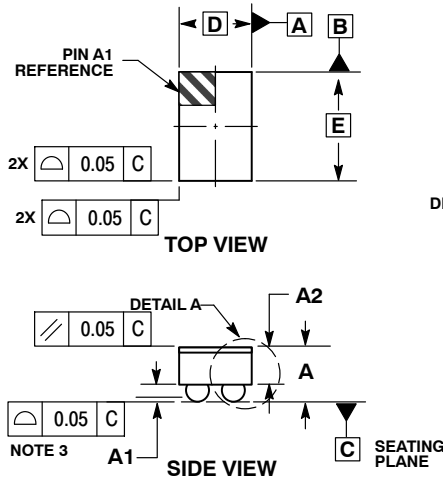
SCALE 4:1

### WLCSP6, 0.80x1.20

#### CASE 567FY

#### ISSUE B

DATE 15 SEP 2016

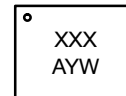


**NOTES:**

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

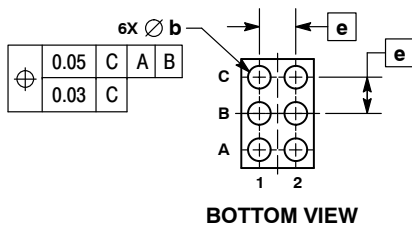
MILLIMETERS		
DIM	MIN	MAX
A	---	0.60
A1	0.17	0.23
A2	0.28	REF
A3	0.04	REF
b	0.21	0.25
D	0.80	BSC
E	1.20	BSC
e	0.40	BSC

### GENERIC MARKING DIAGRAM\*

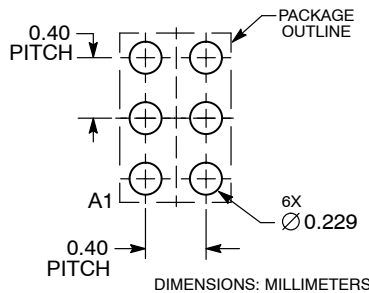


- A = Assembly Location
- Y = Year
- W = Work Week

\*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\*



\*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>WLCSP6, 0.80X1.20</b>	<b>PAGE 1 OF 1</b>

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