

# NCP392C

## Adjustable Front End Overvoltage Protection Controller with Protected Vbus Output

The NCP392C is an overvoltage front end protection controller and is able to disconnect the systems from its output pin in case wrong input operating conditions are detected, up to +28 V. Thanks to this device using internal NMOS, no external device is necessary, reducing the system cost and the PCB area of the application board.

Internal OVLO threshold is available, or can be adjusted if an external resistor bridge is used.

At power up ( $\overline{EN}$  pin = low level), the Vout turns on tstart time after internal timer elapsed.

The NCP392C features an  $\overline{ACOK}$  pin that indicates faulty condition.

### Features

- Over-voltage Protection Up to + 28 V
- On-chip Low  $R_{DS(on)}$  NMOS Transistors: Typical 34 m $\Omega$
- Over-voltage Lockout (OVLO)
- Externally Adjustable OVLO
- Internal 15 ms Startup Delay
- Shutdown  $\overline{EN}$  Input
- $\overline{ACOK}$  Status Pin
- + 100 V Surge Capability, in Compliance with IEC61000-4-5 Standard
- Compliance to IEC61000-4-2 (Level 4) Standard
  - 8 kV (Contact)
  - 15 kV (Air)
- ESD Ratings:
  - Machine Model = B (200 V)
  - Human Body Model = 2 (2 kV)
- CSP-12 Package 1.3 x 2.0 mm, 0.4 mm Pitch
- This is a Pb-Free Device

### Typical Applications

- Cell Phones
- Tablets
- Camera Phones
- Digital Still Cameras
- Personal Digital Applications



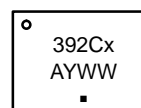
ON Semiconductor®

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WLCSP 12  
FCC SUFFIX  
CASE 567JM

### MARKING DIAGRAM



392Cx = Specific Device Number  
(x = R or S)

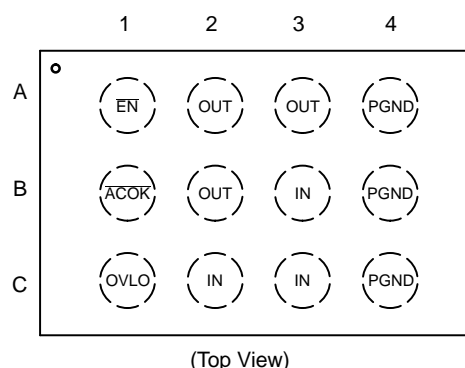
A = Assembly Location

Y = Year

WW = Work Week

■ = Pb-Free Package

### PIN CONNECTION



### ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 9 of this data sheet.

# NCP392C

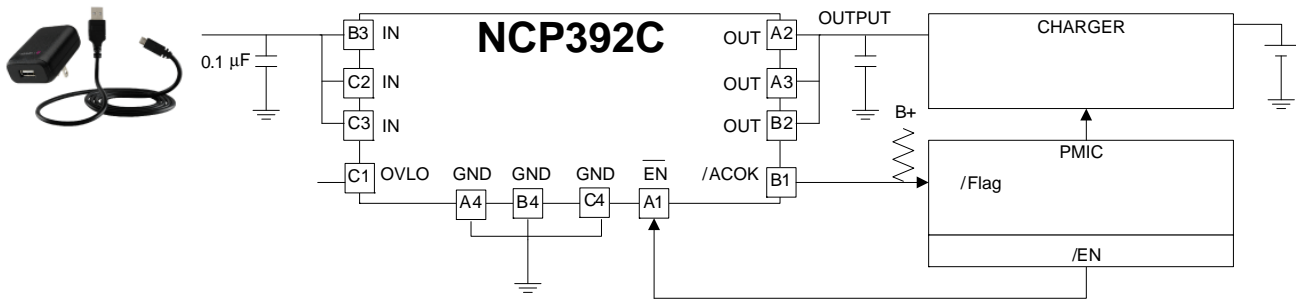


Figure 1. Typical Application Circuit

## FUNCTIONAL BLOCK DIAGRAM

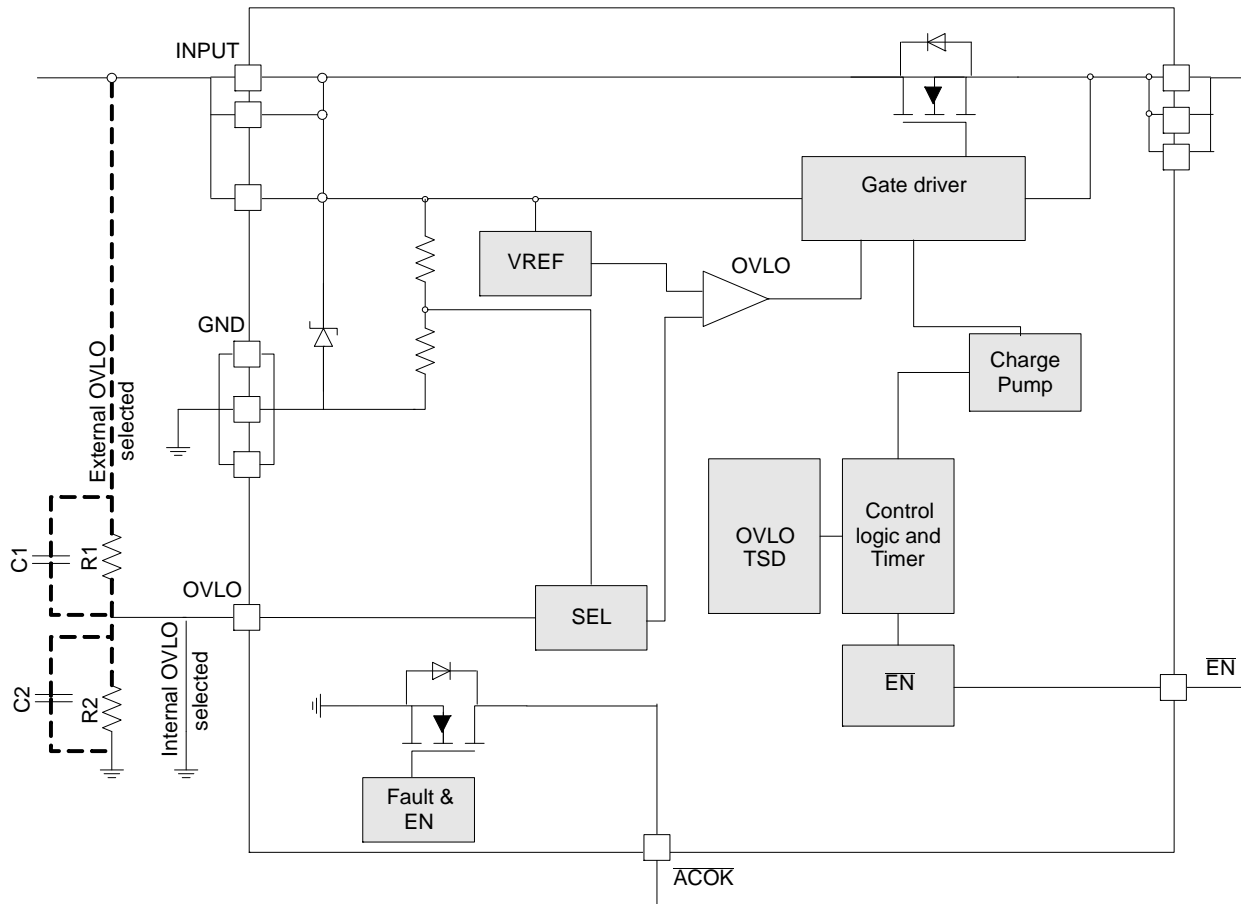
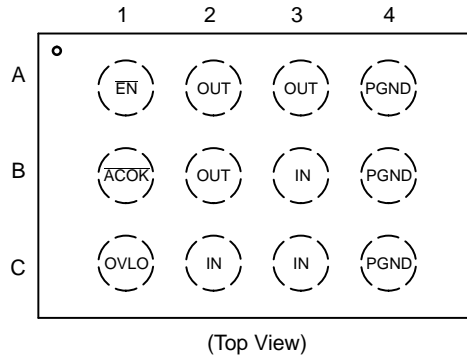


Figure 2. Functional Block Diagram

# NCP392C

## PIN FUNCTION DESCRIPTION



**Figure 3. Pinout**

**Table 1. NCP392 PIN DESCRIPTION**

Pin	Pin Name	Type	Description					
A1	EN	I/O	Enable pin bar. 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.					
A2, A3, B2	OUT	OUTPUT	Output voltage pins. These pins follow IN pins, with debounce time, when “no fault” are detected. The outputs are disconnected from the $V_{in}$ power supply when the input voltage is below UVLO, above OVLO threshold or internal thermal protection is exceeded. The three OUT pins must be hardwired together and used for power dissipation.					
A4, B4, C4	PGND	POWER	Ground. The three GND pins must be hardwired together and connect to the system GND.					
B1	ACOK	OUTPUT	ACOK pin: fault indication pin. Open drain. This pin is tied low if $V_{in}$ is within UVLO and OVLO range.	<table border="1"> <tr> <td>1</td> <td><math>V_{IN} &lt; V_{UVLO}</math> or <math>V_{IN} \geq V_{OVLO}</math></td> </tr> <tr> <td>0</td> <td>Voltage stable</td> </tr> </table>	1	$V_{IN} < V_{UVLO}$ or $V_{IN} \geq V_{OVLO}$	0	Voltage stable
1	$V_{IN} < V_{UVLO}$ or $V_{IN} \geq V_{OVLO}$							
0	Voltage stable							
B3, C2, C3	IN	POWER	Input voltage pins. These pins are connected to the power supply. The three IN pins must be hardwired together.					
C1	OVLO	INPUT	External OVLO Adjustment. Connect external resistor bridge to OVLO pin to select a different OVLO threshold. Connect OVLO pin to GND if not used. In this case internal OVLO will be selected.					

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**Table 2. MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Minimum Voltage (IN, OVLO to GND)	V <sub>minIN</sub>	-0.3	V
Minimum Voltage (All others to GND)	V <sub>min</sub>	-0.3	V
Maximum Voltage (IN to GND)	V <sub>maxIN</sub>	29	V
Maximum Voltage (OVLO to GND)	V <sub>maxOVLO</sub>	14	V
Maximum Voltage (OUT to GND)	V <sub>maxOUT</sub>	22	V
Maximum Voltage (All others to GND)	V <sub>max</sub>	7	V
Maximum DC current	I <sub>max</sub>	4.5	A
Peak input current	I <sub>peak</sub>	8	A
Thermal Resistance, Junction-to-Air	R <sub>θJA</sub>	70	°C/W
Operating Ambient Temperature Range	T <sub>A</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C
Junction Operating temperature	T <sub>J</sub>	+ 125	°C
ESD Withstand Voltage (IEC 61000-4-2) Human Body Model (HBM), model = 2 (Note 1) Machine Model (MM) model = B (Note 2)	V <sub>esd</sub>	15 kV air, 8 kV contact 2000 V 200 V	kV V V
Moisture Sensitivity	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. Human Body Model, 100 pF discharged through a 1.5 kΩ resistor following specification JESD22/A114.
2. Machine Model, 200 pF discharged through all pins following specification JESD22/A115

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**Table 3. ELECTRICAL CHARACTERISTICS**

Min / Max limits values ( $-40^{\circ}\text{C} < T_A < +85^{\circ}\text{C}$ ) and  $V_{in} = +5\text{ V}$  (Unless otherwise noted). Typical values are  $T_A = +25^{\circ}\text{C}$ .

Characteristics	Symbols	Conditions	Min	Typ	Max	Unit	
Input Voltage Range	$V_{in}, V_{OVLO}$		2.8		28	V	
Under voltage Lockout	UVLO	$V_{in}$ rising			2.8	V	
Under voltage Lockout hysteresis	$UVLO_{hyst}$	$V_{in}$ falling	–	60	–	mV	
Internal Over voltage Lockout threshold	OVLO	$V_{in}$ rising (Note 3) OVLO pin tied to GND – $25^{\circ}\text{C}$	NCP392CR	13.4	13.8	14.2	V
			NCP392CS	15	15.5	16	
Internal Over voltage Lockout hysteresis	$OVLO_{hyst}$	$V_{in}$ falling (Note 3) OVLO pin tied to GND – $25^{\circ}\text{C}$	1.5		2.5	%	
External OVLO Reference	OVLO_EXT	NCP392CR	1.12	1.20	1.24	V	
		NCP392CS	1.18	1.221	1.26		
External Adjustable OVLO			4		20	V	
Over-Voltage Lockout Hysteresis	$OVLO_{EXThyst}$	$V_{in}$ falling		2		%	
External OVLO select threshold	$OVLO_{SEL}$		0.2		0.3	V	
Vin versus Vout Resistance	$R_{DSon}$	$V_{in} = 5\text{ V}, \overline{EN} = \text{GND}, -40^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$		34	50	$\text{m}\Omega$	
Supply Quiescent Current	$I_{DD}$	No load, $\overline{EN} = 0.4\text{ V}$		58	100	$\mu\text{A}$	
Standby Current	$I_{STB}$	No load, $\overline{EN} = 1.2\text{ V}$ ,			6	$\mu\text{A}$	
OVLO Supply current	$I_{IN\_OVLO}$	$V_{OVLO} = 3\text{ V}, V_{IN} = 5\text{ V}, V_{OUT} = 0\text{ V}$		60	100	$\mu\text{A}$	
OVLO select leakage	$I_{OVLO}$				100	nA	

## LOGIC

$\overline{EN}$ Voltage High	$V_{IH}$		1.2			V
$\overline{EN}$ Voltage Low	$V_{IL}$				0.4	V
$\overline{ACOK}$ Output Low Voltage	$V_{OL}$	$I_{SINK} = 1\text{ mA}$		0.4		V

## TIMINGS

Start up time	$t_{START}$	From $V_{in} > 2.8\text{ V}$ to 10% $V_{out}$ , $\overline{EN}$ low		15		ms
Enable time	$t_{EN}$	$V_{in}$ present, From $\overline{EN}$ high to low, 10% $V_{out}$		15		ms
Soft Start	$t_{RISE}$	From 10% to 90% of $V_{out}$ , C load 100 $\mu\text{F}$ , Rload, 100 $\Omega$ , $\overline{EN}$ low		1		ms
$\overline{ACOK}$ Start up time	$t_{START2}$	From $V_{in}$ Valid to $\overline{ACOK}$ tied low, $\overline{EN}$ low or high		30		ms
Turn off time	$t_{OFF}$	Surge off time		100		ns
Disable time	$t_{DIS}$	From $\overline{EN} > 1.2\text{ V}$ to 90% $V_{out}$ . No load		20		$\mu\text{s}$
OVLO Turn off time	$t_{OVLO}$	$V_{in}$ rising 2 V/ $\mu\text{s}$		1.5		$\mu\text{s}$

## TSD

Thermal shutdown	TSD			140		$^{\circ}\text{C}$
Thermal shutdown rearming	TSD rearm			115		$^{\circ}\text{C}$

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

3. Please contact your ON Semiconductor representative for additional OVLO threshold.

Electrical parameters are guaranteed by correlation across the full range of temperature.

# NCP392C

## Operation

The NCP392C provides over-voltage protection for positive voltage surge, up to + 28 V. An additional clamp, between IN and GND, protects the part against surge test, in compliance with IEC 61000-4-5 standard.

A  $\overline{\text{ACOK}}$  open drain fault indicator is provided. This signal indicates whether input voltage is within the valid range.

## Under-voltage Lockout (UVLO)

To ensure proper operation under any conditions, the device has a built-in under-voltage lock out (UVLO) circuit. This circuit has a built-in hysteresis to provide noise immunity to transient conditions.

## Over-voltage Lockout (OVLO)

To protect connected systems on Vout pin from over-voltage, the device has a built-in over-voltage lock out (OVLO) circuit. During over-voltage condition, the output remains disabled until the input voltage is above OVLO - hysteresis.

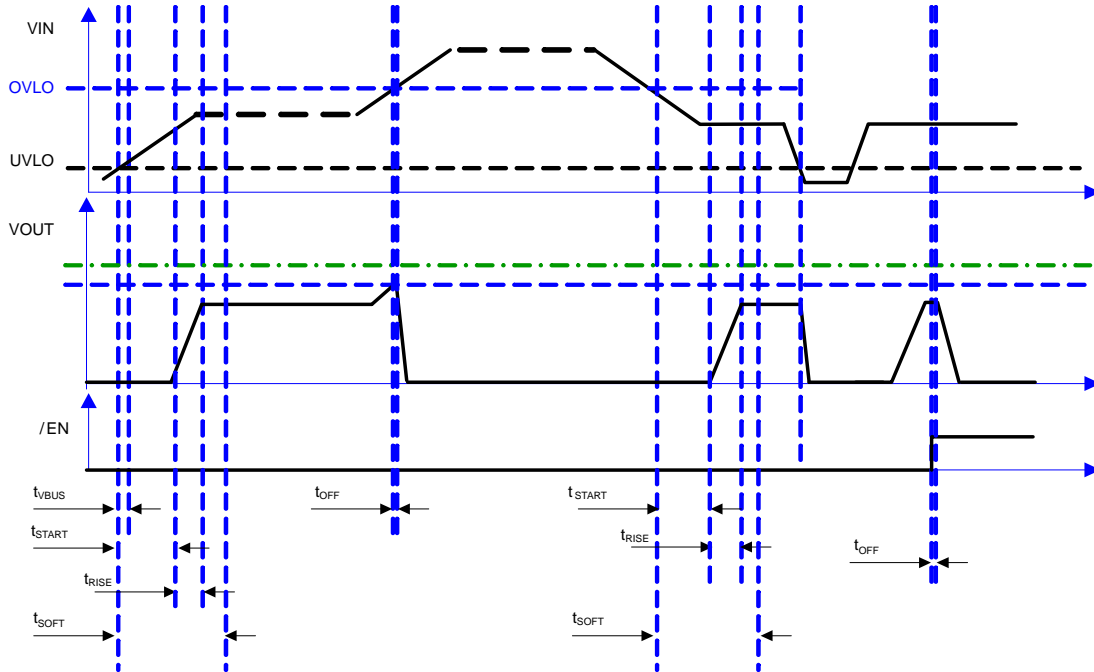


Figure 4. UVLO, OVLO and  $\overline{\text{EN}}$  Functionality

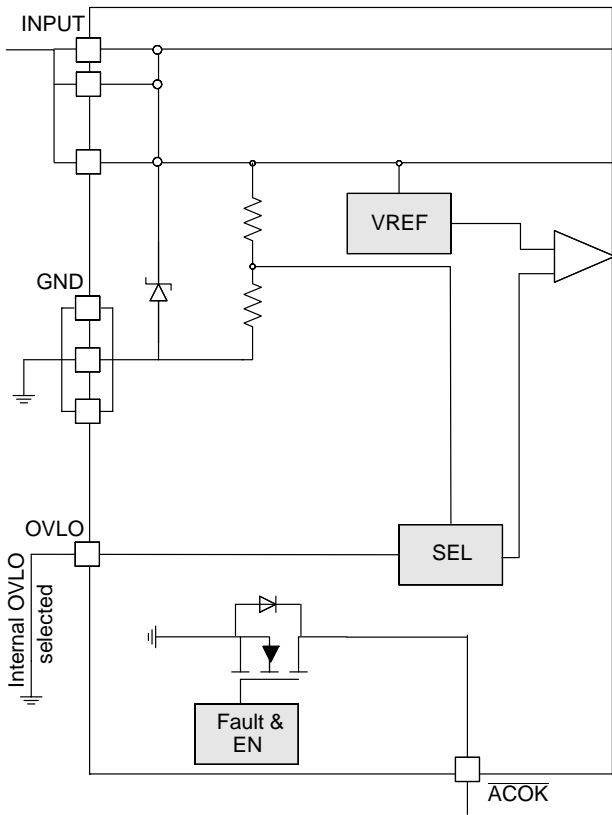


Figure 5. External Connection to GND of OVLO

If OVLO pin is not grounded, and by adding external bridge resistor on OVLO pin, between IN and GND, overvoltage protection can be adjusted as following:

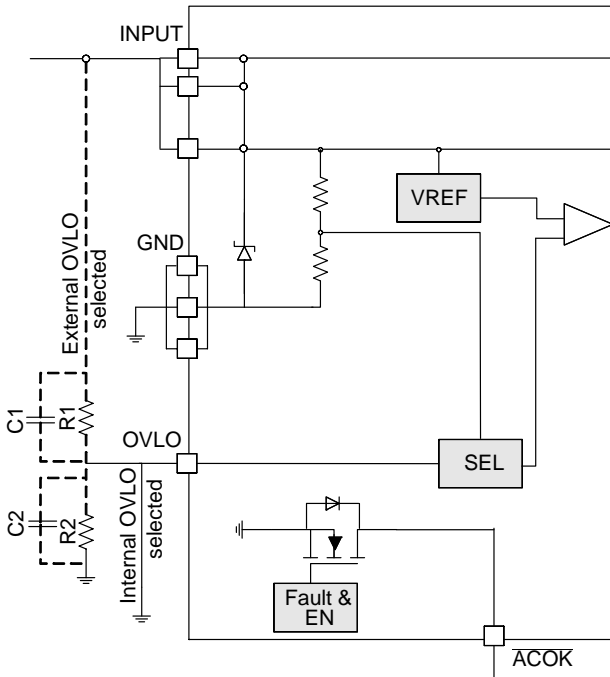


Figure 6. External Connection to Resistor Bridge of OVLO

$$NEW\_OVLO_{TH} = \frac{OVLO_{EXT} \times (R_1 + R_2)}{R_2} \quad (eq. 1)$$

With:  $OVLO_{EXT} = 1.221 \text{ V}$  Typical (OVLO External Reference)

Example:

$NEW\_OVLO_{TH}$  target 12 V.

(eq. 2)

$$R_1 = R_2 \times \left( \frac{OVLO}{1.221} - 1 \right) = R_2 \times \left( \frac{12}{1.221} - 1 \right) = 8.828 \times R_2$$

Taking into account external input bridge doesn't have excessive current consumption, and 1% is recommended:

$R_2$  arbitrarily fixed at  $1.05 \text{ M}\Omega$ .

$R_1 = 9.269 \text{ M}\Omega$  ( $9.31 \text{ M}\Omega$  standard value)

Obtained typical  $OVLO = 12.04 \text{ V}$

$C_1$  and  $C_2$  should be selected in such a way that the time constant  $R_1C_1 = R_2C_2$ .

### EN Input

To enable normal operation, the  $\overline{EN}$  pin has to be at low level. There is neither internal pull up, nor internal pull down connected to  $\overline{EN}$  pin. If not externally driven, this pin and so NCP392C switch are undefined state.

A high level on the pin, disconnects OUT pin from IN pin.

Table 4. CONTROL LOGIC MODES

OVP State NCP392Cx		OVLO EXT	
		Low	High
$\overline{EN}$	Low	ON $T_{start} 15 \text{ ms}$	OFF
	High	OFF	OFF

# NCP392C

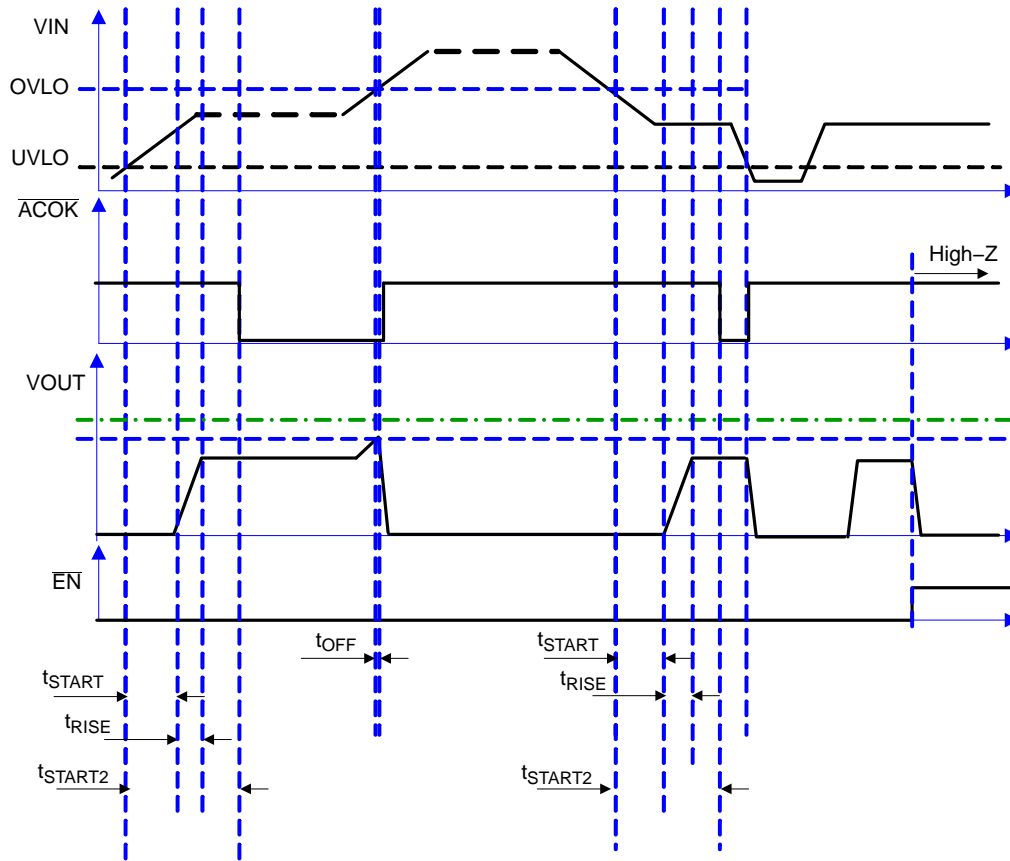


Figure 7. EN and ACOK Associated Timers

## ACOK Pin

The NCP392C version integrates a  $\overline{\text{ACOK}}$  status indicator. This is a drain pin tied low when no fault is present (no TSd, no under voltage, no over voltage).

When disabled, the  $\overline{\text{ACOK}}$  feature is disabled too and the output pin is in high impedance mode.

## Thermal Shutdown Protection

In case of internal overheating, the integrated thermal shutdown (TSD) protection allows to open the internal MOSFET in order to instantaneously decrease the device temperature.

Embedded hysteresis allows to reengage the MOSFET when the junction temperature decreases.

If the fault event is still present, the temperature increases again and engages the thermal shutdown one more time until fault event disappeared.

## PCB Recommendations

To limit internal power dissipation, PCB routing must be carefully done to improve current capability.

The NCP392C is declined in a CSP package. So power dissipation can be decreased on each pin connection but main thermal area must be as large as possible around IN and OUT pins. Taking into account and respectively, four IN and OUT pins must be hardwired together on the PCB.

Maximum power dissipation can be calculated with the following formula:

$$T_J - T_A = R_{\theta JA} \times P_d \quad (\text{eq. 3})$$

$T_J$ : junction temperature

$T_A$ : ambient temperature

$R_{\theta JA}$ : thermal resistance of the junction to air through the case and board.

$P_d$ : power dissipation =  $R_{DS(on)} \times I^2$

## ESD Tests

The NCP392C fully supports the IEC61000-4-2, level 4 (Input pin, 1  $\mu\text{F}$  mounted on board).

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

Please refer to Figure 8 to see the IEC 61000-4-2 electrostatic discharge waveform.



# NCP392C

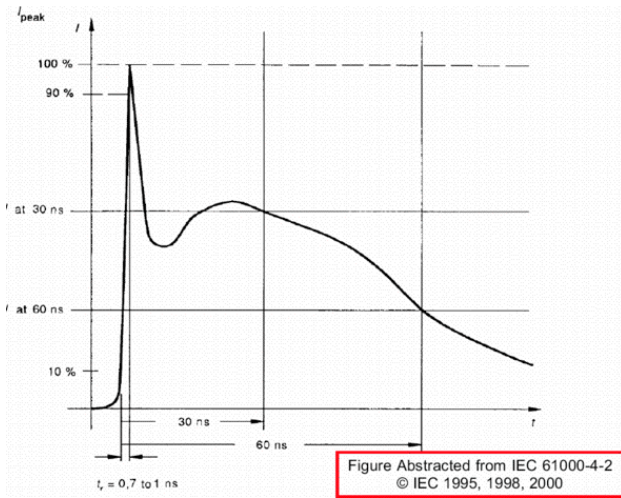


Figure 8.  $I_{peak} = f(t)$  / IEC61000-4-2

## USB OTG Support

When used in an application that has to supply voltage to an external accessory (i.e. USB OTG), the part is able to supply 1.8 A to the accessory. If  $V_{IN} = 0$  V when +5.0 V OTG is applied to the OUT pin, current will flow through the MOSFET body diode and, as soon as the output voltage will be higher than the  $V_{UVLO}$  voltage (2.8 V) plus Body diode forward voltage, the part will turn fully ON and current will be supplied to the accessory with minimum drop.

In that case, the  $\overline{ACOK}$  pin will keep High-Z state.

## ORDERING INFORMATION

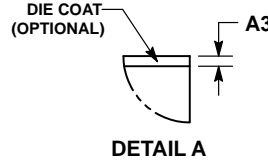
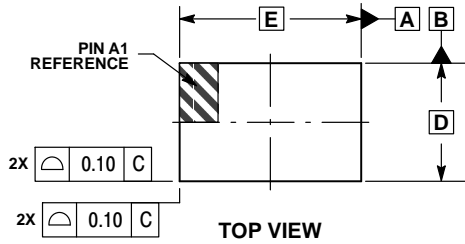
Device	Marking	Option	Package	Shipping <sup>†</sup>
NCP392CRFCCT1G	392CR	OVLO 13.8 V	WLCSP (Pb-Free)	3000 / Tape & Reel
NCP392CSFCCT1G	392CS	OVLO 15.5 V		

<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.

# NCP392C

## PACKAGE DIMENSIONS

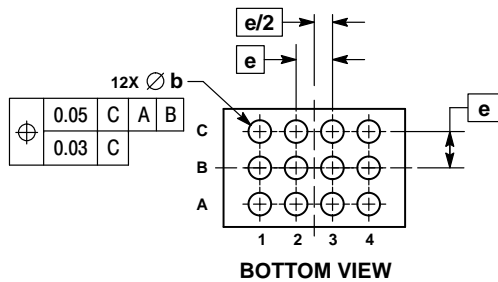
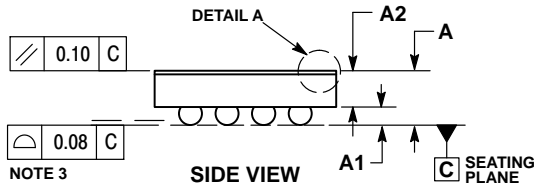
### WLCSP12, 1.3x2.0 CASE 567JM ISSUE A



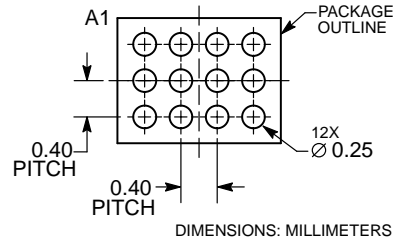
NOTES:

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	0.36 REF	
A3	0.04 REF	
b	0.24	0.30
D	1.26	1.31
E	2.01	2.04
e	0.40 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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